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RESEARCH MEMORANDUM

WIND-TUNNEL INVESTIGATION AT LOW SPEEDS OF VARIOUS PLUG-AILERON AND LIFT-FLAP CONFIGURATIONS ON A 42° SWEPTBACK SEMISPAN WING

By

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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WIND-TUNNEL INVESTIGATION AT LOW SPEEDS OF VARIOUS PLUG-AILERON AND LIFT-FLAP CONFIGURATIONS ON A 42° SWEPTBACK SEMISPAN WING

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SUMMARY

A wind-tunnel investigation has been performed on a 42° sweptback-wing model to determine the lateral control characteristics of a plug-aileron configuration consisting of six segments extending from the wing 20-percent-span to the wing 80-percent-span stations and placed perpendicular to the free-stream flow with the center of each plug segment on the wing 70-percent-chord line. The basic plug aileron and several modifications thereof were investigated for a range of plug projections through a large angle-of-attack range. In addition, several types of lift flaps were investigated and a full-span slotted-flap configuration was developed. The plug-aileron characteristics were determined with the full-span slotted flap in the optimum location. The lateral control characteristics of a partial-span plain sealed aileron were also determined for comparison with the plug-aileron results.

Of the various flap configurations investigated on this wing (full-span slotted flap at deflections of 30°, 40°, and 50°, a half-span slotted flap at 50° deflection, and a half-span split flap and a half-span Zap flap both at 60° deflection), the full-span slotted flap at 30° deflection gave the most satisfactory calculated trimmed-gliding characteristics for an airplane with an assumed wing loading of 40 pounds per square foot and a tail length of 3.0 mean aerodynamic chords.

The results show that the plug aileron investigated with the faired plug-slot lower lip gave positive rolling-moment coefficients at all projections throughout the angle-of-attack range investigated, although there was a large reduction in rolling-moment coefficient at all projections at angles of attack above the wing-tip stall angle. The maximum values of rolling-moment coefficient produced by the plug aileron with the faired lower lip were about 130 percent larger with the full-span slotted flap deflected than with the flap neutral.

The total maximum rolling-moment coefficient resulting from 40° total deflection of a 49-percent-span by 20-percent-chord aileron was about the same as that produced by the plug aileron with the full-span slotted flap deflected. The aileron rolling-moment coefficients with the partial-span slotted flap deflected were equal to or only slightly greater than those with the flap neutral.

INTRODUCTION

The spoiler type of control device has been proposed in reference 1 as a means of lateral control for sweptback wings. All of the spoiler configurations reported in reference 1, however, had some of the objectionable characteristics normally associated with spoilers on unswept wings; namely, a large reduction in rolling-moment coefficient at high angles of attack and low or reversed effectiveness at small spoiler projections for all angles of attack. Unpublished data showing the favorable rolling-moment characteristics in the transonic speed range obtained by one of the more satisfactory spoiler configurations of reference 1 indicated that further work toward improving the low-speed characteristics of spoilers on swept wings would be desirable. References 2 and 3 reported that the plug aileron (formed by the installation of a slot through the wing behind the spoiler) on unswept wings eliminated the objectionable rolling-moment characteristics exhibited by plain spoilers. References 2 and 3 further showed that the installation of a full-span slotted flap, in addition to giving high maximum lift coefficients for landing, greatly improved the rolling-moment effectiveness of the plug aileron.

Reported herein are the results of a high-lift and lateral-control investigation performed on a 42° sweptback semispan-wing model in the Langley 300 MPH 7- by 10-foot tunnel. The high-lift characteristics of a full-span slotted flap were determined on this model for a range of flap deflections and positions, and an attempt was made to improve the maximum lift characteristics of the full-span slotted flap by the installation of flap-slot flow-control vanes. The high-lift characteristics of a half-span slotted flap at one deflection and position and of a half-span Zap flap were also determined. A comparison of the calculated trimmed-gliding characteristics of the 42° sweptback wing under an assumed set of airplane conditions and equipped with several types and spans of lift flaps was made. Included in the lateral-control part of the investigation were the determination of the lateral control characteristics of a basic plug aileron and several revisions thereof. In addition, the characteristics of a 49-percent-span by 20-percent-chord plain aileron were determined for comparison with the plug-aileron results. Also determined were the lateral control characteristics of the most satisfactory plug-aileron configuration with the full-span slotted flap deflected to its optimum deflection and position and of the partial-span aileron with the partial-span slotted flap deflected.

SYMBOLS AND CORRECTIONS

The forces and moments on the wing are presented about the wind axes. The X-axis is in the plane of symmetry of the model and is parallel to the tunnel air flow. The Z-axis is in the plane of symmetry of the model and is perpendicular to the X-axis. The Y-axis is perpendicular to both the X-axis and Z-axis. All three axes intersect at a point 37.22 inches rearward of the leading edge of the wing root on the line of intersection of the plane of symmetry and the chord plane of the model, as shown in figure 1.

C_L lift coefficient $\left(\frac{\text{Twice lift of semispan model}}{qS}\right)$

C_{L_t} trimmed lift coefficient

C_D drag coefficient (D/qS)

C_m pitching-moment coefficient about Y-axis $(M/qS\bar{c})$

C_l rolling-moment coefficient about X-axis (L/qSb)

C_n yawing-moment coefficient about Z-axis (N/qSb)

D twice drag of semispan model, pounds

M twice pitching moment of semispan model about Y-axis, foot-pounds

L rolling moment due to plug projection or aileron deflection about X-axis, foot-pounds

N yawing moment due to plug projection or aileron deflection about Z-axis, foot-pounds

q dynamic pressure, pounds per square foot $\left(\frac{1}{2}\rho V^2\right)$

S twice area of semispan model, 32.24 square feet

$\bar{c}$ wing mean aerodynamic chord (M.A.C.), 2.89 feet $\left(\frac{2}{S}\int_0^{b/2} c^2\,dy\right)$

b twice span of semispan model measured along Y-axis, 11.36 feet

c' local wing chord measured along lines perpendicular to wing trailing edge

c	local wing chord measured along lines parallel to X-axis, feet
y	lateral distance from plane of symmetry along Y-axis, feet
V	free-stream velocity, feet per second
V_s	sinking velocity, feet per second
V_g	gliding velocity, miles per hour
ρ	mass density of air, slugs per cubic foot
α	angle of attack with respect to chord plane of model, degrees
δ_p	plug-aileron projection, percent local wing chord, negative when plug is projected above wing upper surface
δ_a	aileron deflection measured in planes perpendicular to aileron hinge axis, degrees
δ_f	flap deflection measured in planes perpendicular to flap leading edge, degrees
R	Reynolds number

The rolling-moment and yawing-moment coefficients represent the aerodynamic effects that occur on a complete wing as a result of deflection of the control on one semispan of the complete wing; the lift, drag, and pitching-moment coefficients represent the aerodynamic effects that occur on the complete wing as a result of deflection of the lift flap on both semispans of the complete wing.

The test data have been corrected for blockage and jet-boundary effects, including the reflection-plane corrections to the rolling-moment and yawing-moment coefficients. The variation of the corrections to the rolling-moment and yawing-moment coefficients with span of the lateral-control device is presented in reference 1. The rolling-moment and yawing-moment coefficient corrections applied to the data presented herein were taken directly from reference 1 for the span of the control device under consideration.

No corrections were made to the data to account for wing twist caused by control deflections or projections or flap deflection.

APPARATUS AND MODEL

The right semispan sweptback-wing model was mounted in the Langley 300 MPH 7- by 10-foot tunnel as shown in figure 2. The root chord of the model was adjacent to the ceiling of the tunnel, the ceiling thereby serving as a reflection plane. The model was mounted on the balance system in such a manner that all forces and moments acting on the model could be measured. A small clearance was maintained between the model and the tunnel ceiling so that no part of the model came in contact with the tunnel structure. A root-fairing strip was attached to the model to deflect the air that flows into the tunnel test section through the clearance hole between the model and the tunnel ceiling so as to minimize the effects of any such inflow on the flow over the model.

The model had 42° of sweepback referred to the wing leading edge, an aspect ratio of 4.01, and was constructed of laminated mahogany to the plan form shown in figure 1. The airfoil section normal to the 0.272 chord line was constant throughout the span and was of NACA 64_1-112 airfoil profile. The tip of the wing was rounded off beginning at $0.975\frac{b}{2}$ in both plan form and cross section. The model had no geometric twist or dihedral.

The full-span 20-percent-chord slotted flap was built to the plan form and section dimensions shown in figures 3 and 4, respectively. The flap was fitted with an attachment bracket at three spanwise locations and each bracket could be adjusted to give several flap deflections and a range of positions of the flap nose with relation to the wing trailing-edge upper-surface lip. A partial-span slotted flap was formed by cutting the flap at the 51-percent-span station on a line parallel to the model plane of symmetry. The details of flap-slot flow-control vanes A and B investigated on the semispan-wing model are presented in figures 5 and 6, respectively. A half-span Zap-type flap investigated on the semispan-wing model was built of thin plywood and was deflected down 60° about a hinge line on the wing trailing edge (fig. 7). The small slot between the flap leading edge and the wing trailing edge was sealed.

The plan form and section dimensions of the basic plug ailerons investigated are shown in figures 3 and 8, respectively. The plug ailerons were built in six segments of $\frac{1}{4}$-inch aluminum plate and had $\frac{1}{8}$-inch-thick steel actuating arms screwed to the ends of each plug segment. A clamp was provided on each actuating arm to hold the plug aileron at the desired projection. The plugs could be adjusted through a range of projections from 0 percent to -7 percent of the local wing chord. In addition, the plug aileron was investigated with the slot lower lip refaired from the original sharp lip to a smooth air inlet as shown in figure 9.

The 20-percent-chord by 49-percent-semispan plain aileron investigated was formed by cutting the flap on a line parallel to the wing plane of symmetry. The plain aileron was sealed and was held at the various deflections (ranging from 20° to −20°) by steel straps on both the wing upper and lower surfaces.

Transition was not fixed for any of the tests.

TESTS

The slotted-flap, plug-aileron, and plain-aileron tests were performed at an average dynamic pressure of approximately 20.5 pounds per square foot, which corresponds to a Mach number of about 0.12, and a Reynolds number of about 2,400,000. The Zap flap test and the plain-wing test performed in conjunction with the Zap flap test were performed at an average dynamic pressure of about 9.1 pounds per square foot, which corresponds to a Mach number of about 0.07 and a Reynolds number of about 1,600,000. Both Reynolds numbers are based on the wing mean aerodynamic chord of 2.89 feet.

The tests, in general, were run through a range of angle of attack of −10° to 26°.

RESULTS AND DISCUSSION

The lift, drag, pitching-moment, and calculated trimmed-gliding characteristics of the 42° sweptback semispan-wing model are presented in figures 10 to 16. The rolling-moment and yawing-moment characteristics of the various plug-aileron and plain-aileron configurations, both flap-neutral and flap-deflected, are presented in figures 17 to 22.

Wing Aerodynamic Characteristics

Flap retracted.- The aerodynamic characteristics of the wing with various plug-slot configurations are shown in figure 10. It may be seen from figure 10 that at an angle of attack of about 16°, regardless of the plug-gap or lower-lip configuration, the slope of the pitching-moment-coefficient curve becomes markedly unstable and the drag starts to increase rapidly. A visual study of the behavior of tufts on the upper surface of the wing showed that a sudden stalling of approximately the outboard 40 percent of the wing occurred at this angle of attack. This abrupt stall may be a condition encountered only at the low Reynolds number at which the tests were performed. The results of previous unpublished tests in the Langley 19-foot pressure tunnel of a complete wing (with individual panels having the same geometric characteristics as the wing reported herein) through a large range of Reynolds number indicated that at the higher Reynolds number, the break in the pitching-moment curve would be delayed to a higher angle of attack and the abrupt nature of the stall would be somewhat relieved.

Figure 10 shows little variation of the wing aerodynamic characteristics with variation in plug-slot configuration other than that a higher drag was obtained with the plug-slot configuration having the faired plug-slot lower lip and with both the upper and lower plug-slot gaps open than with any of the other plug-slot configurations investigated.

Flap deflected.- A series of flap-nose positions was investigated with the full-span slotted flap at deflections of 30°, 40°, and 50°. The results obtained for the most satisfactory flap positions at each particular deflection are presented in figure 11 and show that all three flap configurations gave about the same value of maximum lift. A flap deflection of 30° in the position indicated gave the highest L/D ratio throughout the lift range and is therefore considered to be the optimum flap deflection.

The inboard 51-percent-span slotted flap at 50° deflection is considerably more than half as effective in producing lift as the full-span slotted flap at the same deflection and position. (See fig. 12.) The proportionately higher lifting effectiveness of the inboard partial-span flap as compared with the full-span flap has been noted previously in references 4, 5, and 6 for unswept wings. The pitching-moment coefficients produced by the full-span slotted flap is about three times as great as that produced by the partial-span slotted flap. This effect is as would be predicted on the basis of the analyses of references 7 and 8 which show that the center of load of the wing with the full-span flap is considerably farther behind the aerodynamic center of the wing than is the center of load of the wing with the partial-span inboard flap.

Figure 13 presents a comparison of the aerodynamic characteristics in pitch of the plain wing and the wing with the half-span Zap flap deflected 60°. (These data were obtained at a Reynolds number of 1,600,000.) A comparison of the plain-wing data of figure 13 with the plain-wing data of figure 12 (which was obtained at a Reynolds number of 2,400,000) shows that the maximum value of C_L and the slope of the curve of C_L against α at the high lifts obtained at the lower Reynolds number are somewhat greater than the values obtained at the higher Reynolds number. In addition, a comparison of the Zap flap data of figure 13 with slotted-flap data of figure 12 shows that the Zap flap produced almost as high a maximum value of C_L as the full-span slotted flap but produced about the same increment of C_L as the partial-span slotted flap at lift coefficients below maximum lift. The differences between the plain-wing data at the two Reynolds numbers are probably caused by changes in the physical conditions of the wing model and not by the change in Reynolds numbers since the Zap flap test and the accompanying plain-wing test were performed before the installation of the slotted flap, the plug ailerons, and the various plain-spoiler configurations reported in reference 1. It is believed that the maximum lift coefficients for the full-span and partial-span slotted flaps would have been somewhat higher had the slotted-flap tests been performed with the wing in a condition comparable to that for the Zap flap tests.

Figure 14 presents the trimmed-gliding characteristics of the plain 42° sweptback wing and the wing equipped with various flap configurations. The gliding characteristics were calculated for an airplane having an assumed wing loading of 40 pounds per square foot and a tail length of $3.0\bar{c}$. (The gliding characteristics of the wing with the half-span split flap, presented in fig. 14, were calculated from unpublished data obtained in the Langley 19-foot pressure tunnel.) At a sinking speed V_s of 30 feet per second (assumed to be the maximum permissible) the plain wing had the highest gliding speed, about 135 miles per hour.

At a sinking speed of 30 feet per second the gliding speed decreased to about 132 miles per hour with either the half-span Zap flap or the half-span split flap deflected and decreased to about 118 miles per hour with the half-span slotted flap deflected 50°. The slowest landing speeds (about 110 mph) were obtained with the full-span slotted flap deflected either 30° or 50°. On the basis of these results the full-span slotted flap at 30° deflection is considered to be the most satisfactory flap configuration for this particular wing. The data presented in figure 14 are for relatively low Reynolds numbers. The unpublished data from the Langley 19-foot pressure tunnel indicate that increasing Reynolds numbers result in an increase in the value of maximum lift coefficient which would, of course, result in a somewhat lower landing speed for each of the flap configurations.

Tuft studies of the flow along the wing lower surface in the vicinity of the flap slot with the full-span slotted flap deflected showed a large amount of spanwise air flow toward the wing tip in lines approximately parallel to the flap leading edge. The flap-slot flow-control vanes A and B shown in figures 5 and 6, respectively, were therefore installed on the wing lower surface in the flap slot to interrupt this spanwise flow and to direct it in lines perpendicular to the flap leading edge, thus increasing the dynamic pressure and, consequently, the lift over the flap. The results presented in figure 15 for the wing with tufts and the full-span slotted flap deflected 50° show that the wing lift was decreased and the wing drag increased by the installation of vanes A. The installation of flow-control vanes B on the wing with the full-span slotted flap deflected 50° resulted in an increase in both the wing lift and drag as shown in figure 16. Comparison of the calculated gliding characteristics of the wing with the full-span slotted flap at $\delta_f = 50^\circ$ and vanes B on and off indicated that better gliding characteristics would be obtained for the vanes-off condition. Such may not be the case, however, at other flap deflections.

Lateral Control Characteristics

Plug ailerons (flap retracted).- Figure 17(a) shows the variation with angle of attack of the rolling-moment and yawing-moment coefficients produced by various projections of the plug aileron with the sharp plug-slot lower lip. The rolling-moment coefficient increased with plug-aileron projection and with angle of attack to an angle of attack from 14° to 16°, at which point the rolling-moment-coefficient curve showed a sharp decrease. This decrease is caused by the abrupt tip stalling of this particular wing, as has been mentioned previously. The maximum rolling moment produced by this plug-aileron configuration was obtained at $\delta_p = -7$ percent and was about the same value as that produced by spoiler 18 of reference 1 at the same spoiler projection. In the lower angle-of-attack range, however, the rolling moments were lower for the plug aileron with $\delta_p = -5$ percent and -7 percent than for spoiler 18 of reference 1 at comparable projections and angles of attack. At the lower plug-aileron projections, the rolling moments were higher over the angle-of-attack range than those produced by spoiler 18, and the reversal of rolling moment noted for spoiler 18 did not occur. However, the plug aileron with the sharp plug-slot lower lip was ineffective in producing favorable rolling moment at low plug-aileron projections.

In an attempt to remedy the plug-aileron ineffectiveness at low projections, the plug-slot lower lip was faired to offer a better air inlet (as shown in fig. 9). The faired plug-slot lower lip improved the effectiveness of the plug aileron at all projections and increased the maximum rolling moments approximately 20 percent. (See fig. 17(b).) However, there was still a large reduction in rolling-moment coefficient at all projections at angles of attack above the wing-tip stall angle.

In the low and moderate angle-of-attack range, the yawing-moment coefficients produced by the plug ailerons with either the sharp or the faired plug-slot lower lip were of the same sign (positive) as the rolling-moment coefficients (a condition usually referred to as favorable yaw) and were equal to about 30 to 40 percent of the rolling-moment coefficient at the maximum values of rolling-moment coefficient. The yawing moments usually became negative above an angle of attack of about 11° to 13°, which is in proximity to the angle of attack at which the wing tip stalled and the pitching moments became unstable.

Presented for comparison in figure 18 are the rolling-moment coefficients against plug-aileron projection at various angles of attack for the plug-aileron configurations with a sharp and a faired plug-slot lower lip and for spoiler 18 (from reference 1). These data show the reversal of rolling effectiveness of the spoiler at low projections and the elimination of the reversal by use of the plug aileron. Also shown is the increase in rolling effectiveness (noted previously) obtained with the faired plug-slot lower lip compared to the effectiveness obtained with the sharp plug-slot lower lip.

Plug aileron (flap deflected).- Figure 19 shows the rolling-moment and yawing-moment coefficients produced by the plug aileron with the faired plug-slot lower lip and with the full-span flap deflected 30° at the optimum nose position. In general, the rolling-moment coefficient increased with increasing plug-aileron projection and increased slightly with increasing angle of attack to the angle of attack for the tip stall (approximately 10°). Comparison of the plug-aileron data of figures 17(b) and 19 shows that deflection of the full-span slotted flap resulted in an increase in the maximum rolling-moment coefficient produced by the plug aileron of about 130 percent over the rolling-moment coefficient produced by the plug aileron on the unflapped wing.

At low angles of attack, the yawing-moment coefficients produced by the plug ailerons with the full-span slotted flap deflected were generally of the same sign as the rolling-moment coefficients, except at projections of −1/2 percent and −1 percent where the sign was the opposite of the rolling-moment coefficient. The yawing-moment coefficients were about 10 percent to 15 percent of the rolling-moment coefficient at the maximum value of rolling-moment coefficient. The yawing moments became negative above an angle of attack of about 10° which, for the flap-deflected condition, is the angle of attack at which the wing tip stalled.

Effect of plug-aileron actuating-arm configuration.- The plug-aileron actuating arms were normally open as shown in figure 8. In order to determine the effects of this opening, the actuating arms were filled-in to the wing surface in such a manner as to form a solid actuating arm.

The data of figures 20(a) ($\delta_f = 0°$) and 20(b) ($\delta_f = 50°$) indicate that with the flap neutral, the filled-in actuating arms had little effect on the rolling-moment coefficients produced by the plug aileron. With the flap deflected, however, the rolling-moment coefficients produced by the plug aileron with the filled-in actuating arms were generally lower by as much as 13 percent than the rolling moments produced by the plug aileron with the open actuating arms.

The yawing-moment coefficients produced by the plug aileron with the filled-in actuating arms were slightly higher at the maximum plug projections ($\delta_p = -0.07c$) than those produced by the plug with the open actuating arms. The yawing-moment coefficients produced by the plug at smaller projections were only slightly affected by variation of the actuating-arm configuration.

Effect of gap between wing upper surface and plug-aileron lower edge.- At plug-aileron projections of $\delta_p = -0.03c$ or greater, the lower edge of each plug segment emerged from the upper surface of the wing at the inboard end of the plug segment in such a manner that a wedge-shaped gap existed between the wing upper surface and the plug-segment lower edge. Figure 21 shows that filling in this gap resulted in an appreciable increase in rolling-moment coefficient over that produced in the gap-open condition with the plug at $\delta_p = -0.07c$ but had little effect on the rolling-moment coefficient at $\delta_p = -0.05c$. This effect of gap between the plug lower edge and the wing upper surface has been obtained previously for plug ailerons on unswept wings (references 9 and 10).

Filling-in the gap between the plug-aileron lower edge and the wing upper surface increased slightly the yawing-moment coefficient produced by the plug aileron at both $\delta_p = -0.05c$ and $-0.07c$.

Half-span plain aileron.- The rolling-moment and yawing-moment characteristics of the wing with the 0.20c by $0.49\frac{b}{2}$ ailerons are shown in figure 22(a) with the flap neutral and in figure 22(b) with the half-span slotted flap deflected 50°. For both the flap-neutral and flap-deflected conditions, the rolling-moment coefficient increased with increasing aileron deflections and decreased as the wing angle of attack was increased either positively or negatively from $\alpha = 0^\circ$. At angles of attack below the wing-stall angle, the values of total rolling-moment coefficient, for any combination of equal up-aileron and down-aileron deflections, are equal to or slightly higher for the slotted flap-deflected condition than with the flap neutral.

For both flap conditions, the total yawing-moment coefficient resulting from an equal up and down deflection of the aileron was generally small at angles of attack below the wing stall and was adverse (sign of yawing moment opposite to sign of rolling moment). At angles of attack below the wing-stall angle the total adverse yawing-moment coefficient produced by the aileron on the wing with the flap deflected, although small, was somewhat greater than that produced by the aileron on the wing with the flap neutral. The total yawing-moment coefficients produced by the plain aileron at angles of attack greater than the wing-stall angle were higher than those at low angles of attack for both flap conditions.

<u>Comparison of plug ailerons and the half-span plain aileron.</u>— A comparison of figures 17(b) and 22(a) ($\delta_f = 0^\circ$) and figures 19 ($\delta_f = 30^\circ$) and 22(b) ($\delta_f = 50^\circ$) indicates that the plug aileron has favorable yaw over the usable angle-of-attack range as compared to the adverse yaw present with the plain aileron.

For the flap-neutral condition, the plain aileron gave a maximum rolling-moment coefficient for a total aileron deflection of 40° approximately 130 percent greater than the maximum rolling-moment coefficient produced by the plug aileron at $\delta_p = -0.07c$. For the flap-deflected condition (partial-span flap with the plain aileron and full-span flap with the plug aileron), the maximum value of rolling-moment coefficient produced by the plug aileron was about the same as that produced by $\pm 20^\circ$ deflection of the plain aileron.

At angles of attack above the wing-tip stall angle, the rolling-moment coefficients produced by the plain aileron were much larger than those produced by the plug aileron, regardless of the lift-flap condition.

CONCLUSIONS

The results of an investigation of a 42° sweptback semispan-wing model equipped with several high-lift and lateral-control devices lead to the following conclusions:

1. Of the various high-lift flaps investigated (full-span slotted flap at various positions and deflections, a half-span slotted flap at 50° deflection, a half-span split flap and a half-span Zap flap both at 60° deflection), the full-span slotted flap deflected to 30° gave the most satisfactory calculated landing characteristics for an airplane with an assumed wing loading of 40 pounds per square foot and a tail length of 3.0 mean aerodynamic chords.

2. The plug-aileron arrangement investigated with the faired plug-slot lower lip gave positive rolling-moment coefficients at all projections throughout the wing angle-of-attack range, although there was a large reduction in rolling-moment coefficient at all projections at angles of attack above the wing-tip stall angle. The maximum values of rolling-moment coefficient produced by the plug aileron with the faired lower lip were about 130 percent larger with the full-span slotted flap deflected than with flap neutral.

3. The total maximum rolling-moment coefficient resulting from 40° total deflection of a 49-percent-span by 20-percent-chord aileron was about the same as that produced by the plug aileron with the full-span slotted flap deflected. The aileron rolling-moment coefficients with the partial-span slotted flap deflected were equal to or only slightly greater than those with the flap neutral.

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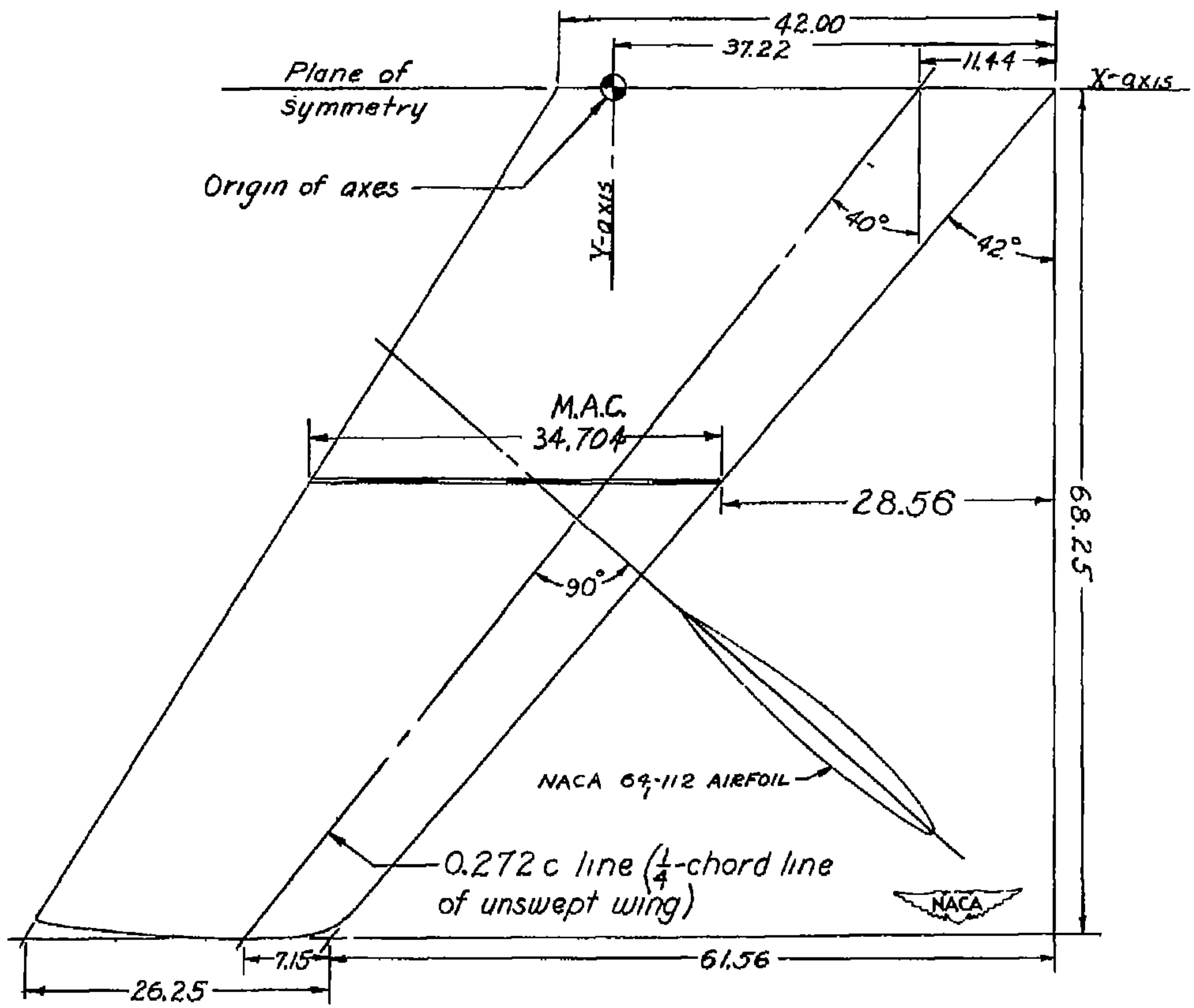
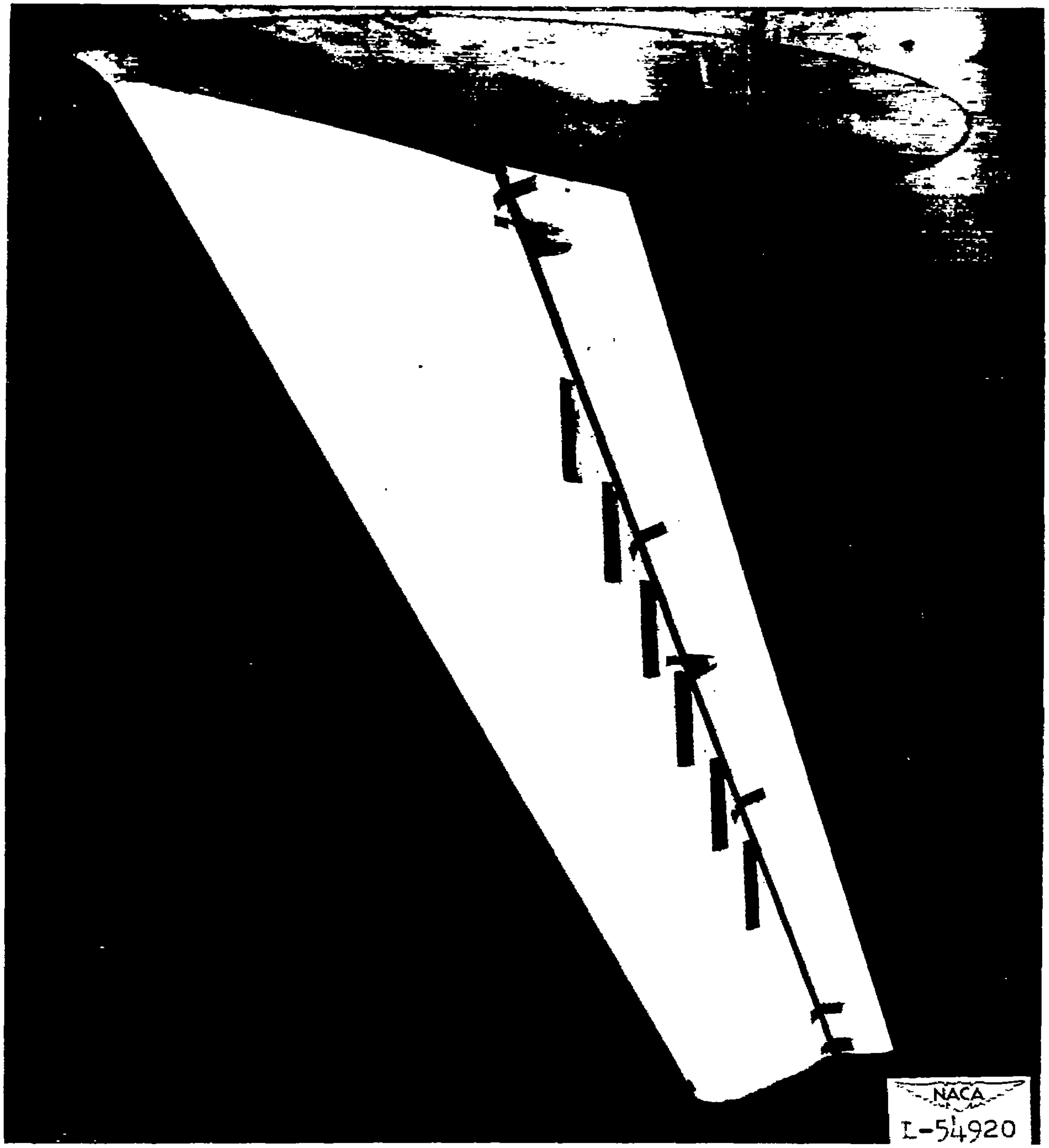


Figure 1.- The 42° sweptback wing. Area, 32.24 square feet; aspect ratio, 4.01; taper ratio, 0.625. All dimensions are in inches unless otherwise noted.



(a) Wing lower surface.

Figure 2.- The 42° sweptback wing mounted in the Langley 300 MPH 7- by 10-foot tunnel. Full-span slotted flap deflected 50°.

(b) Wing upper surface.

Figure 2.- Concluded.

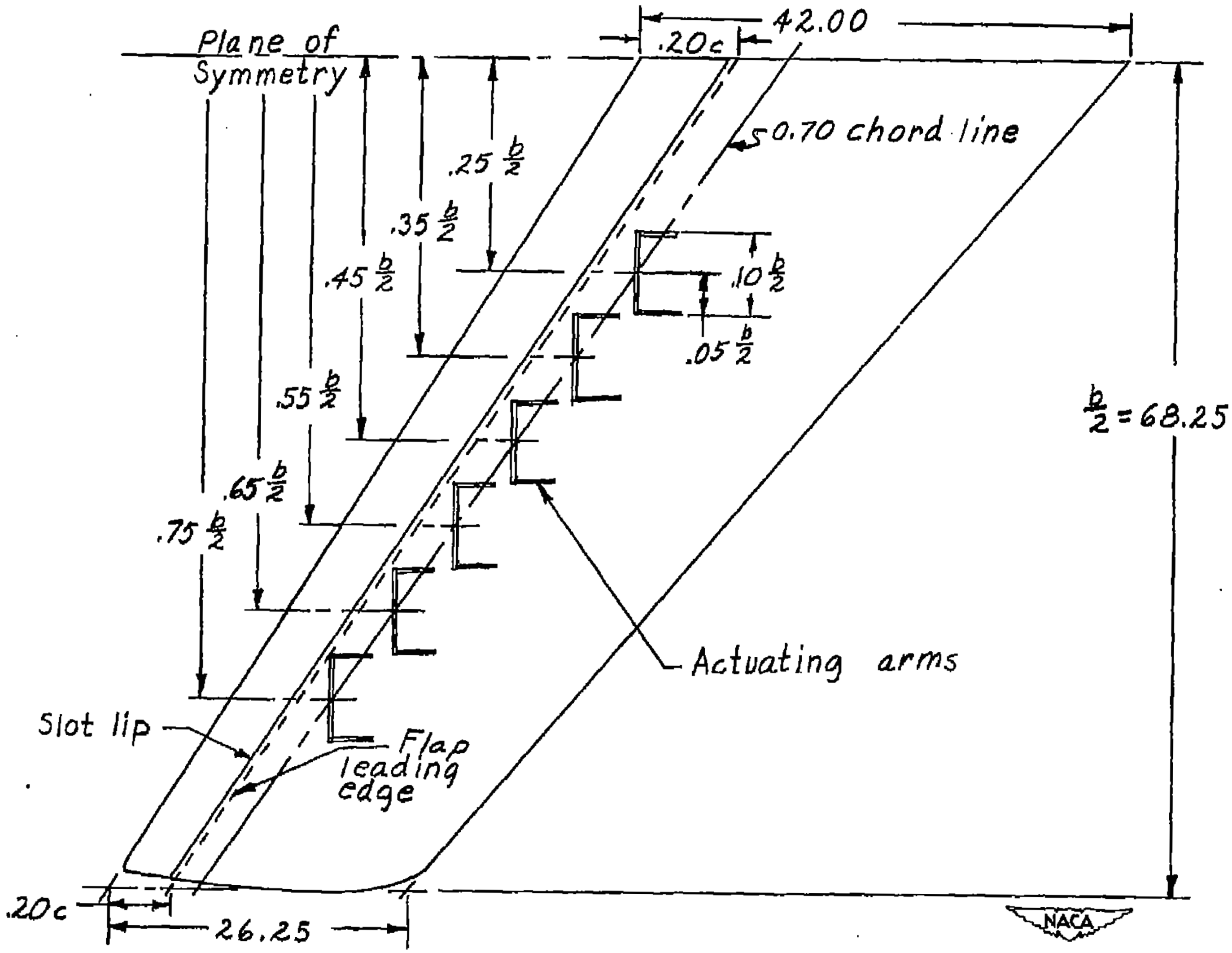
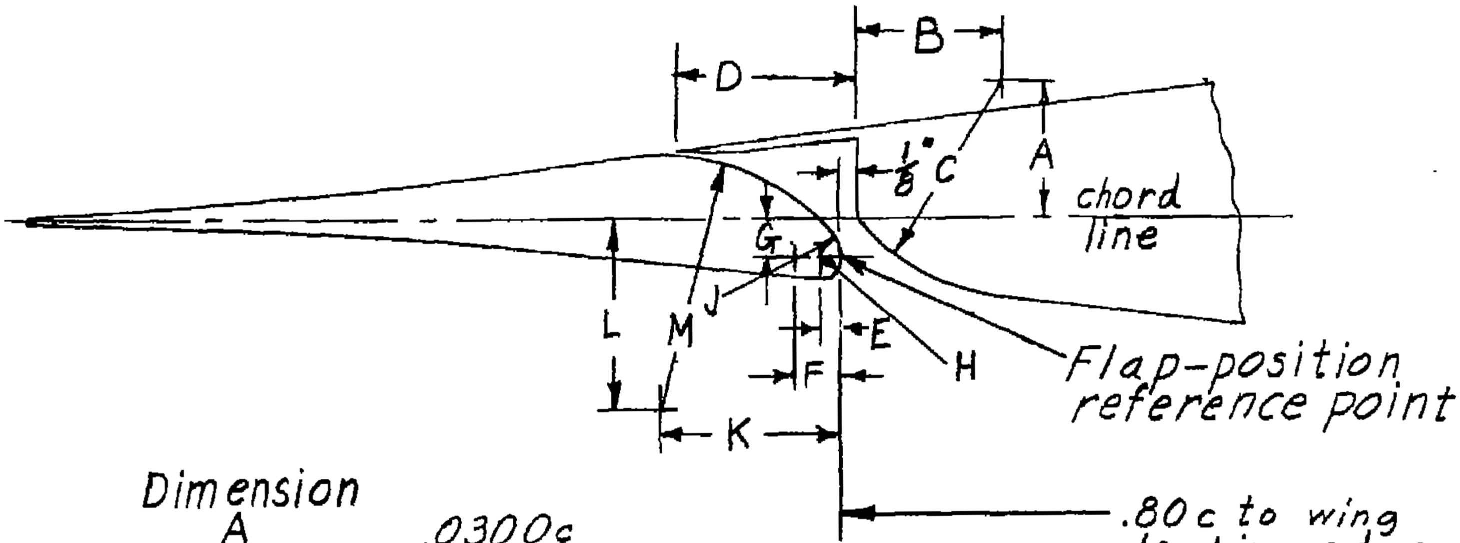


Figure 3.- Plug-aileron and slotted-flap locations on the 42° sweptback wing. All dimensions are in inches unless otherwise noted.



Dimension	
A	.0300c
B	.0374c
C	.0486c
D	.0450c
E	.0050c
F	.0102c
G	.0093c
H	.0050c
J	.0102c
K	.0450c
L	.0450c
M	.0605c
Flap chord	.2000c

Figure 4.- Section dimensions of the slotted flap tested on the 42° sweptback wing.

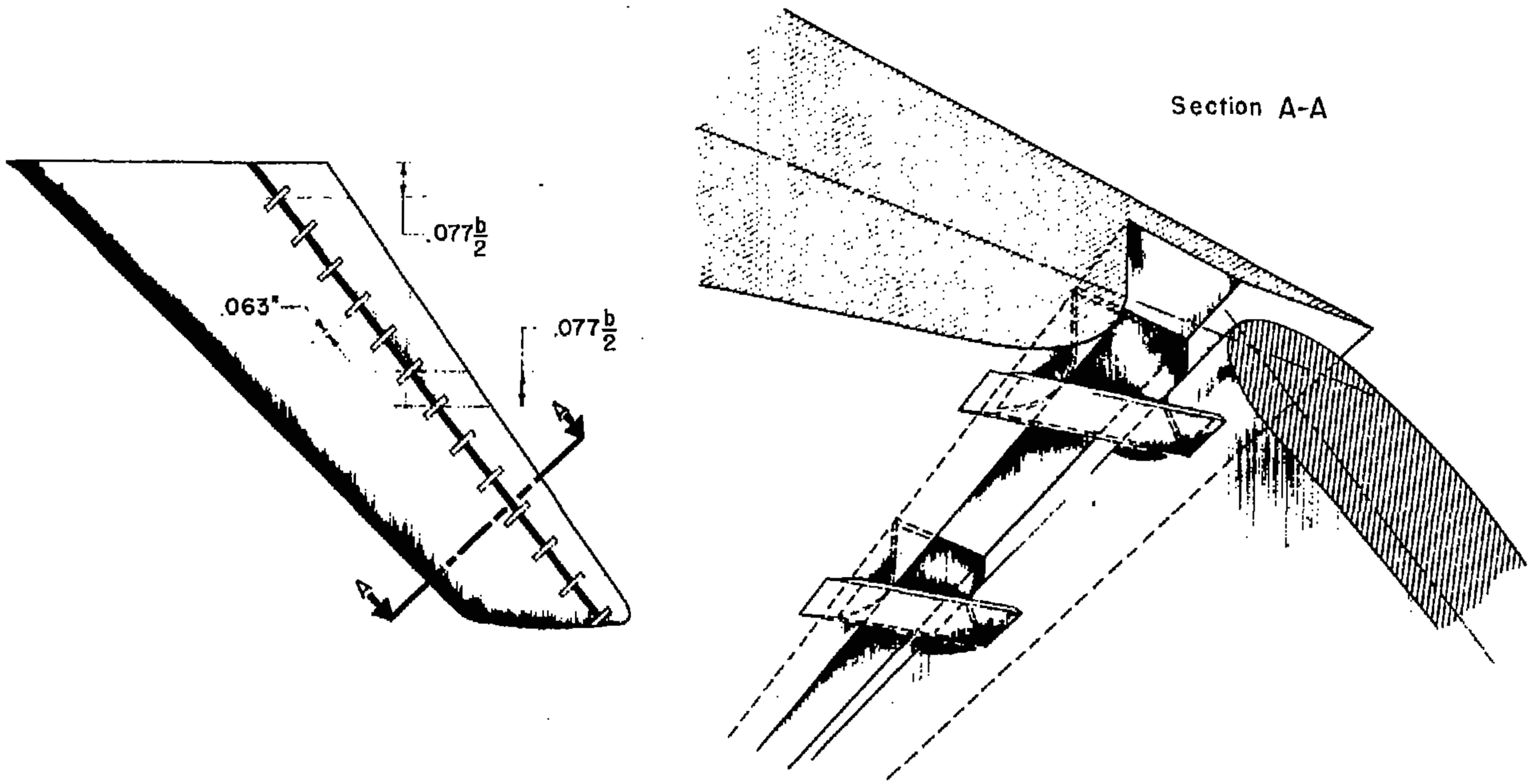


Figure 5.- Locations and details of flap-slot flow-control vanes A on the 42° sweptback wing.

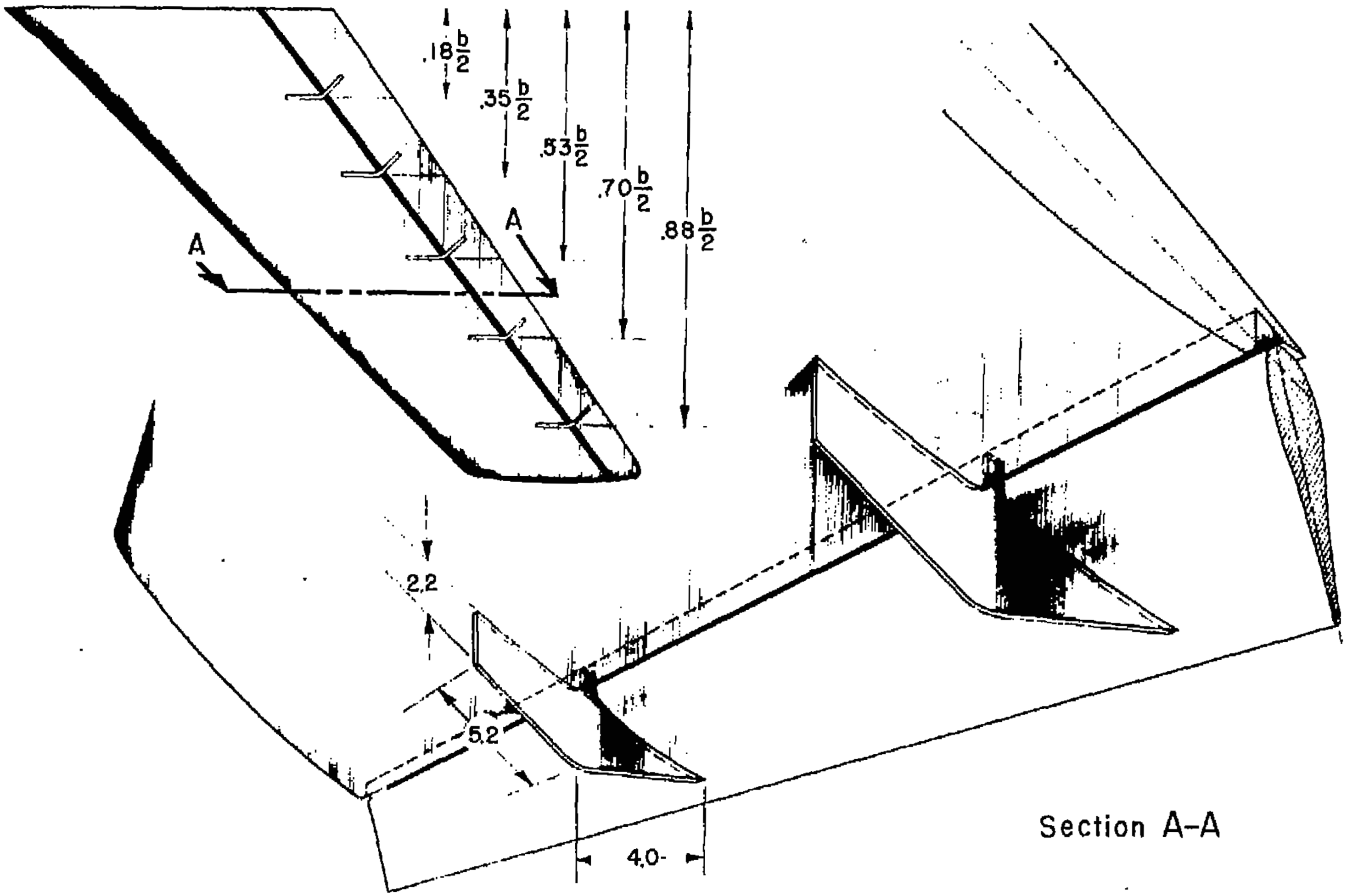


Figure 6.- Locations and details of flap-slot flow-control vanes B on the 42° sweptback wing. All dimensions in inches unless otherwise indicated.

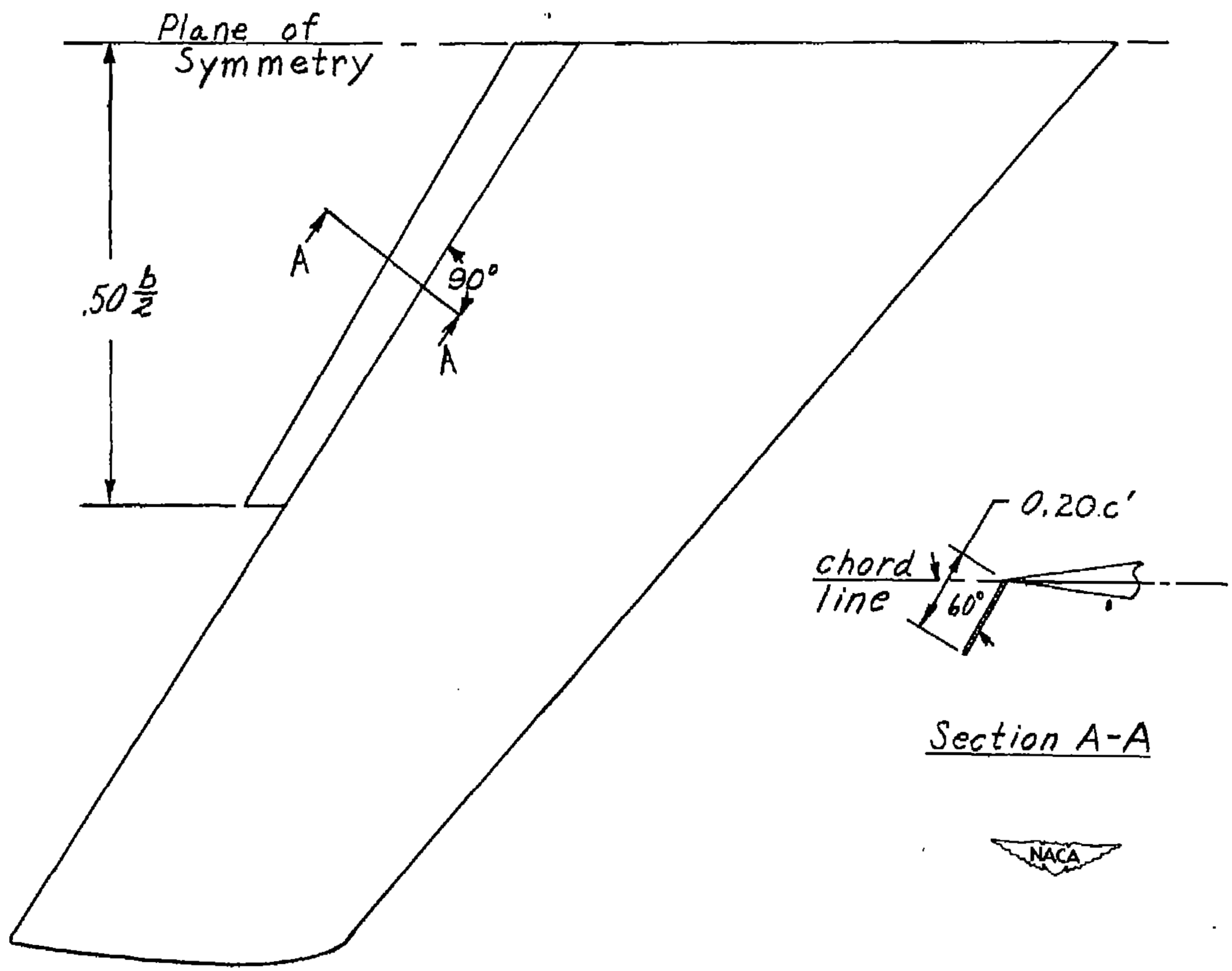


Figure 7.- Details of the half-span Zap flap tested on the 42° sweptback wing.

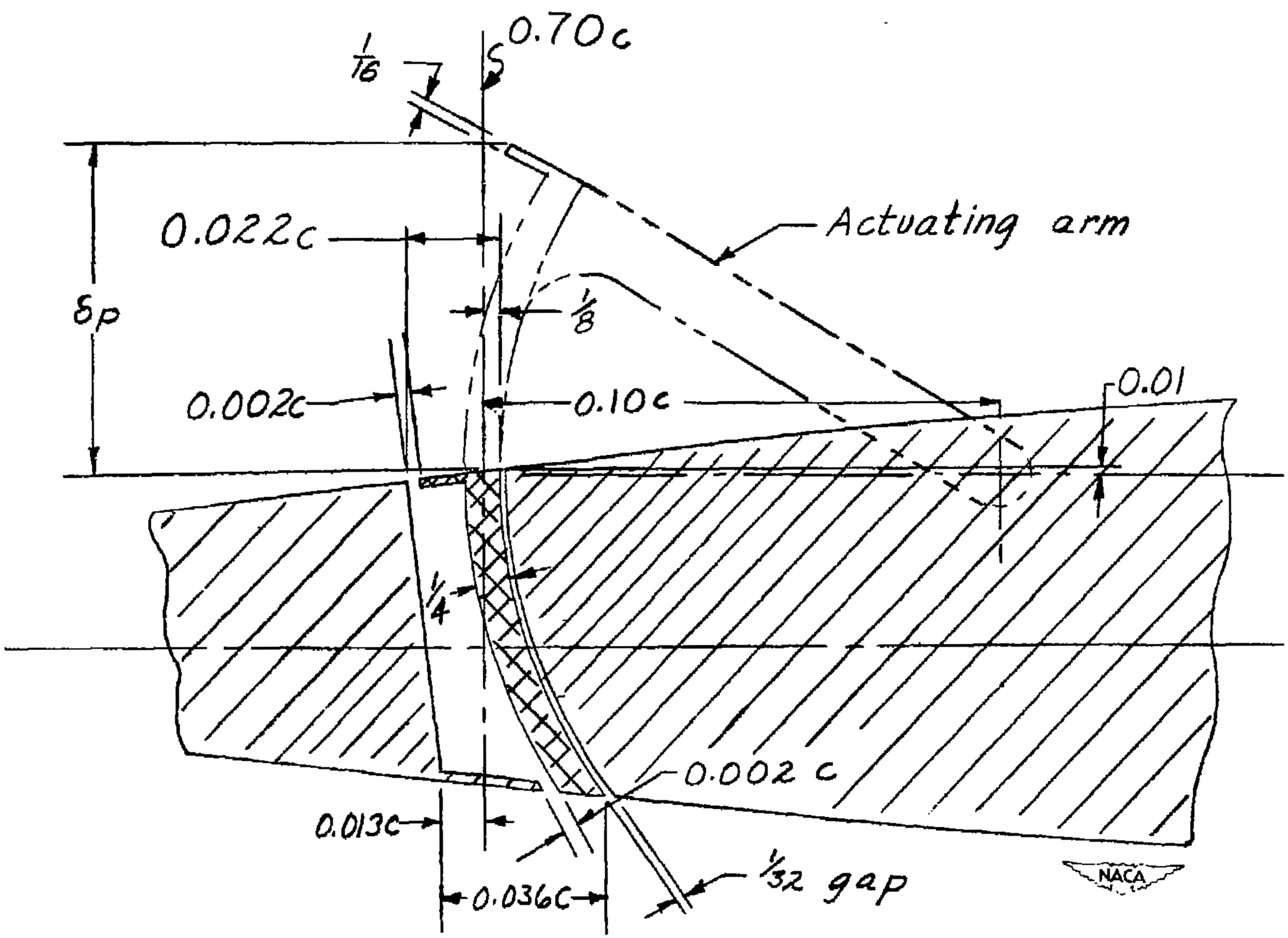


Figure 8.- Section dimensions of the plug aileron with the sharp plug-slot lower lip tested on the 42° sweptback wing. All dimensions are in inches unless otherwise noted.

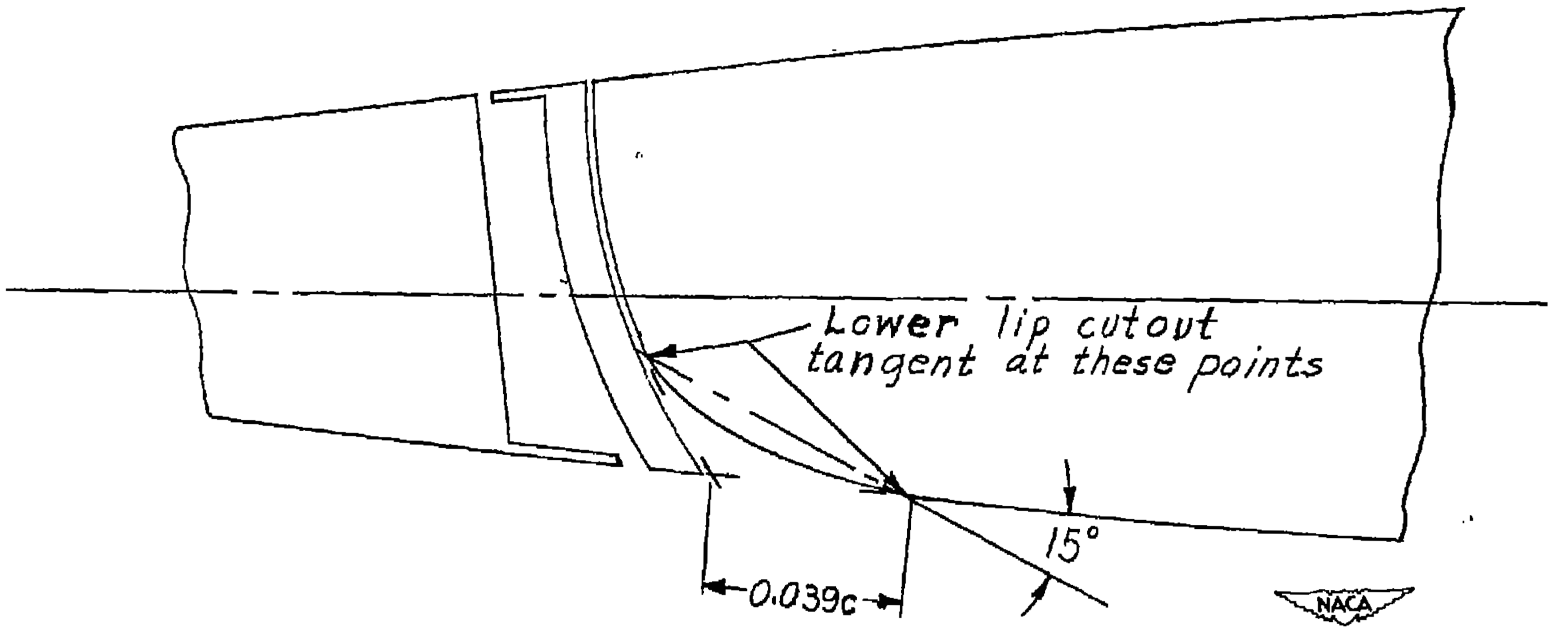


Figure 9.- Details of the faired plug-slot lower lip tested on the 42° sweptback wing.

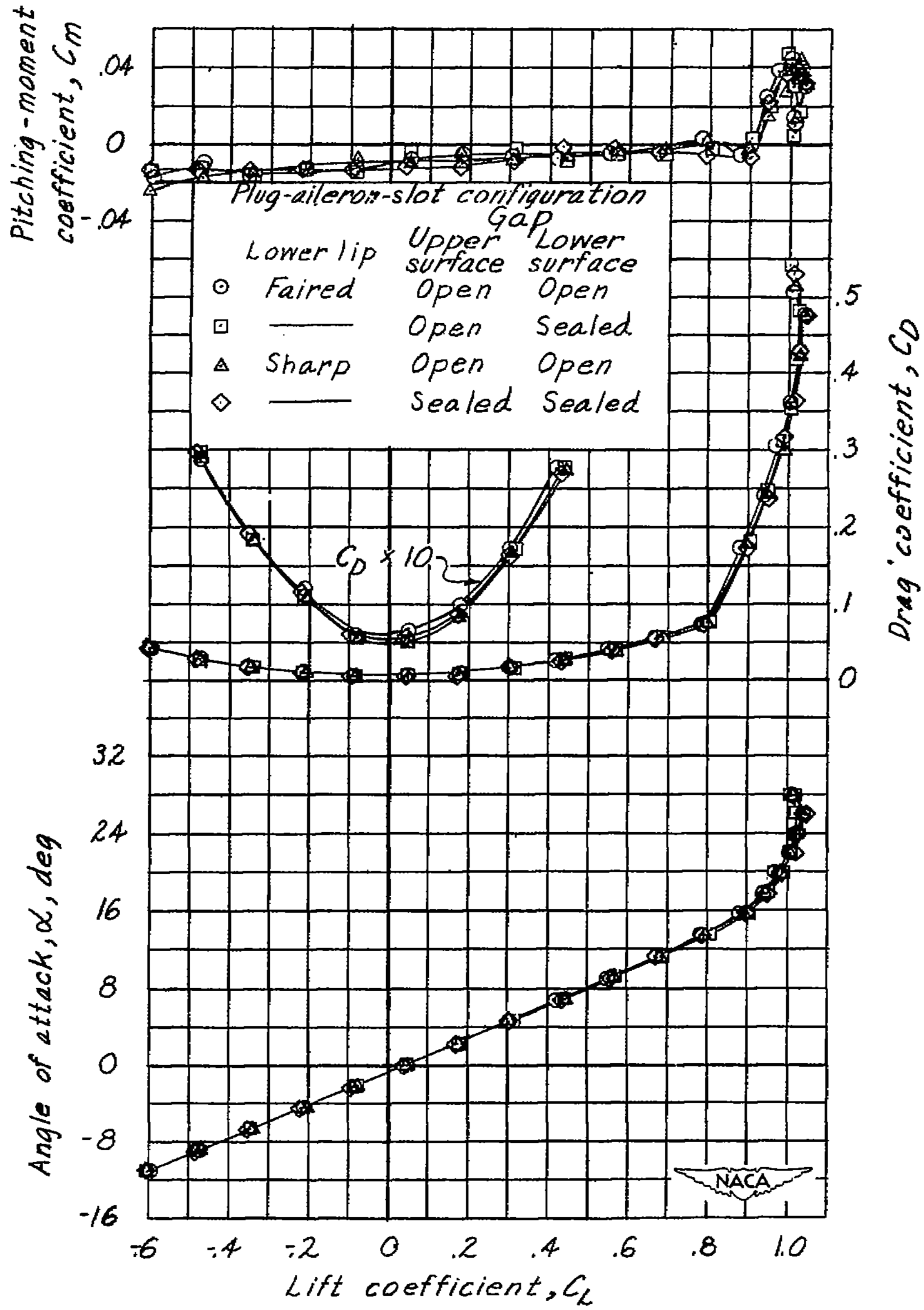


Figure 10.- The aerodynamic characteristics in pitch of the 42° swept-back wing with various plug-aileron-slot configurations. Flap retracted.

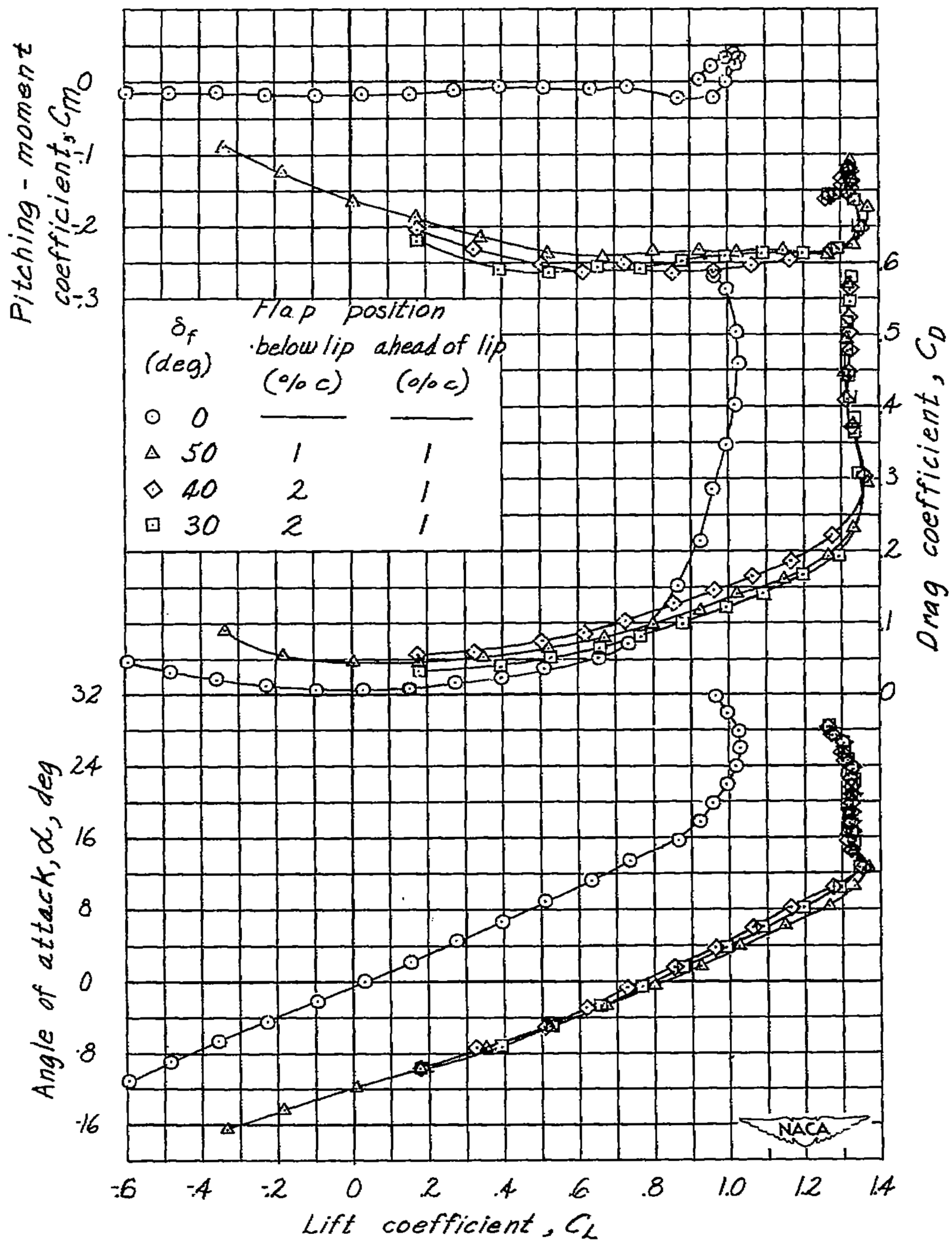


Figure 11.- The aerodynamic characteristics of the plain wing and the wing with a full-span slotted flap at various deflections. The flap position is optimum for each particular deflection.

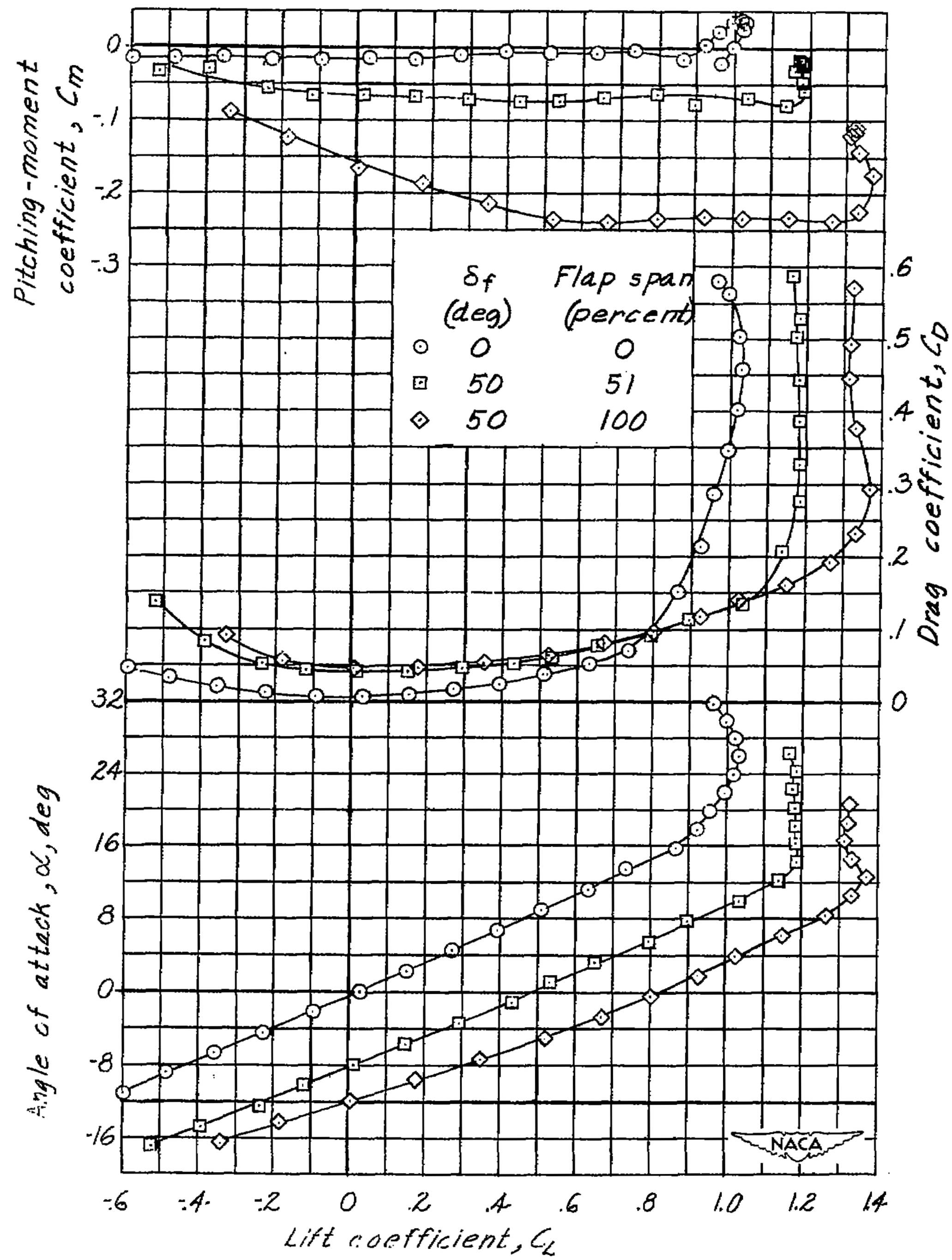


Figure 12.- The effect of span of the slotted flap on the aerodynamic characteristics in pitch of the 42° sweptback wing.

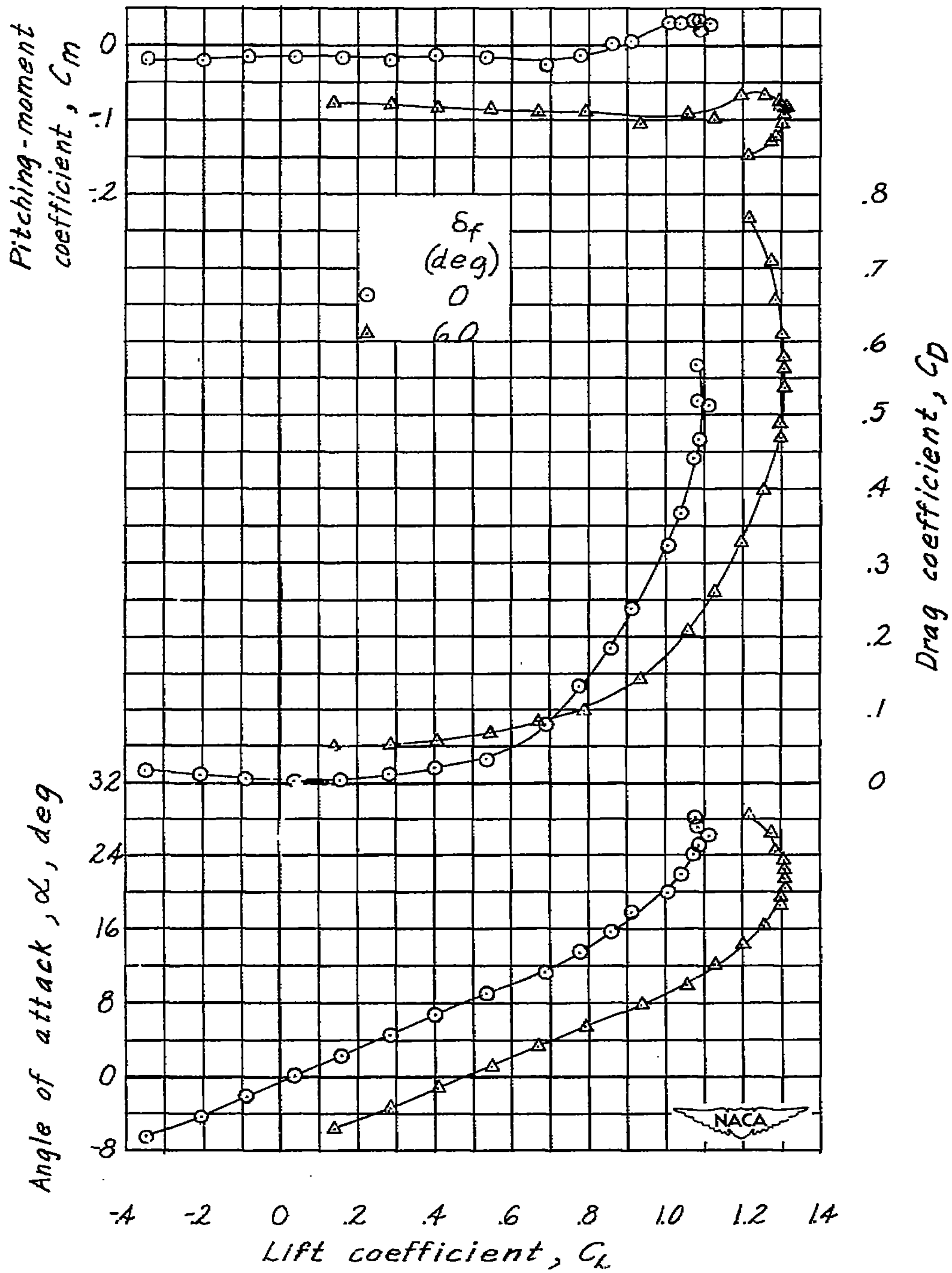


Figure 13.- The effect of deflection of a half-span Zap flap on the aerodynamic characteristics in pitch of the 42° sweptback wing.

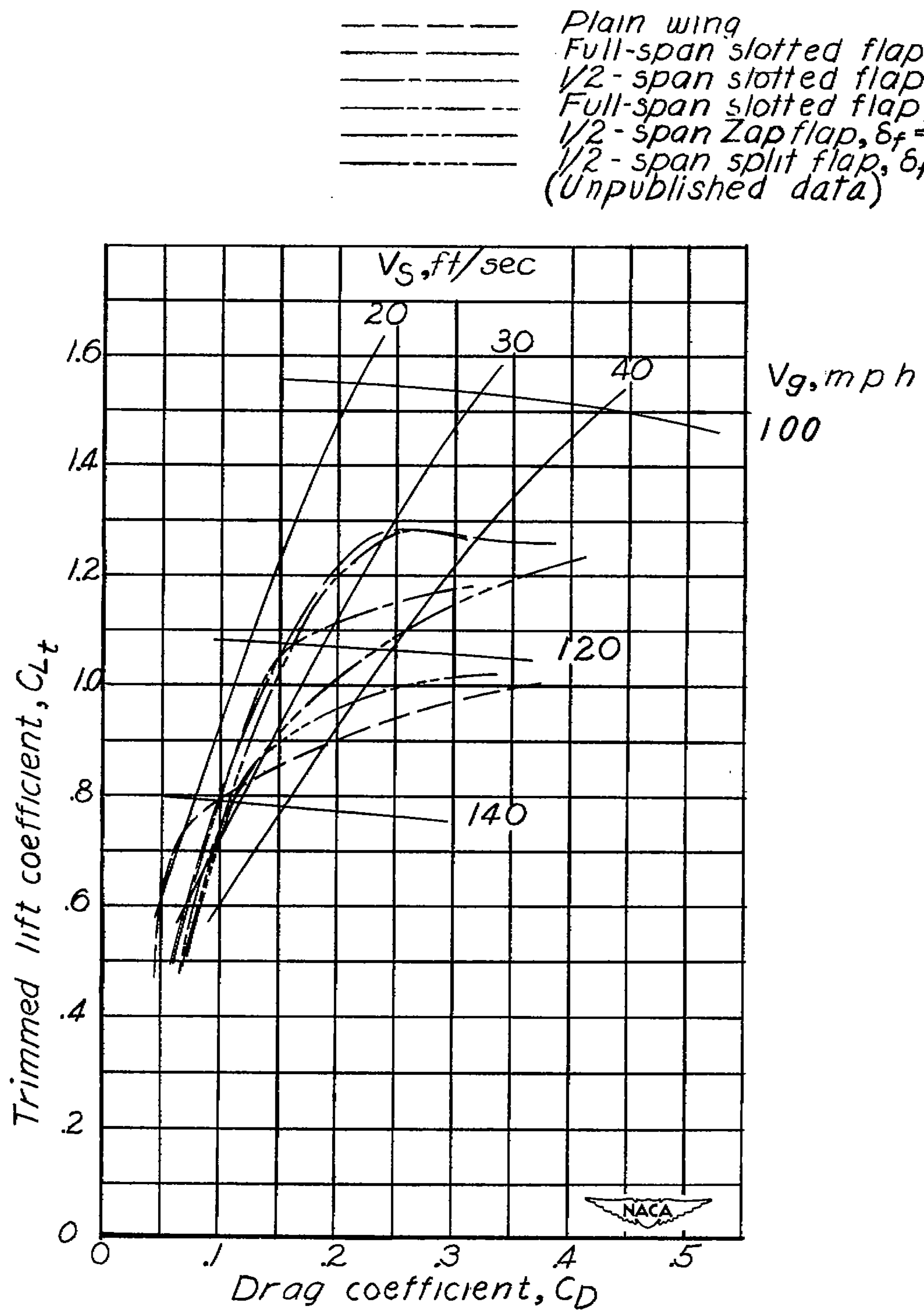


Figure 14.- Gliding characteristics of the 42° sweptback wing in trimmed flight. Wing loading, 40 pounds per square foot; tail length, $3.0\bar{c}$.

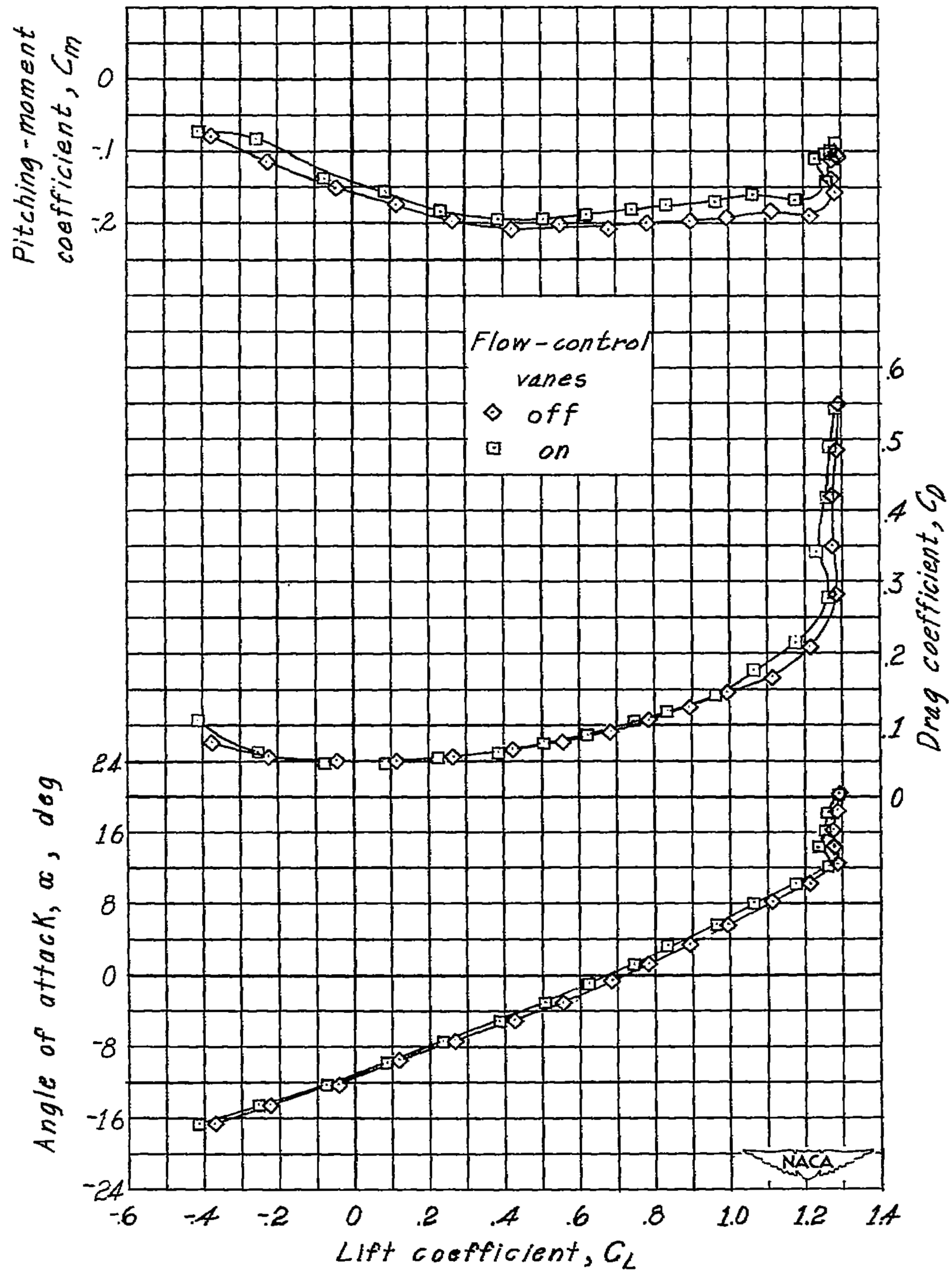


Figure 15.- The effect of flap-slot flow-control vanes A on the aerodynamic characteristics in pitch of the 42° sweptback wing with the full-span slotted flap deflected 50°. Flap position, 1 percent below lip and 1 percent ahead of lip. Tufts on.

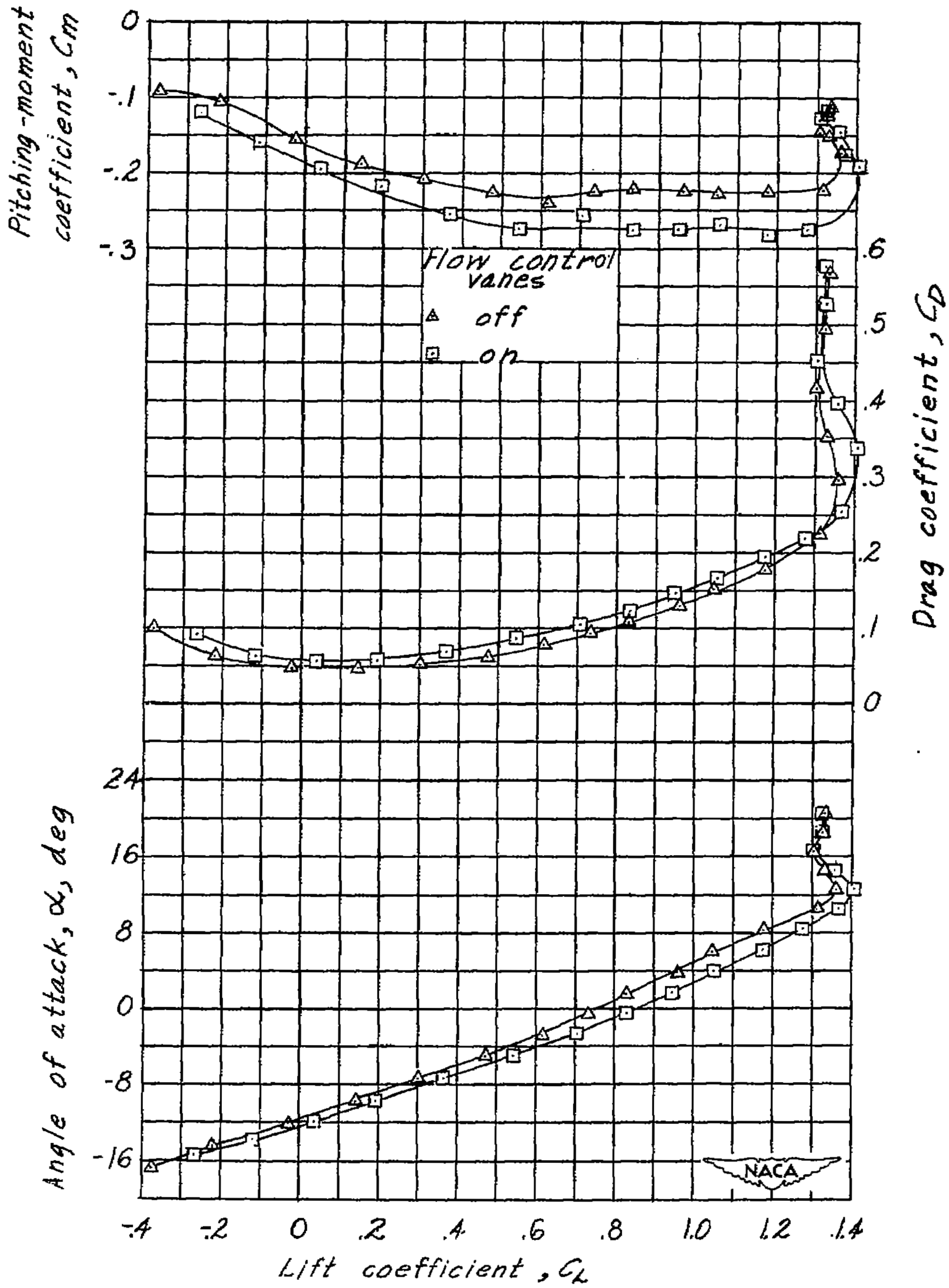
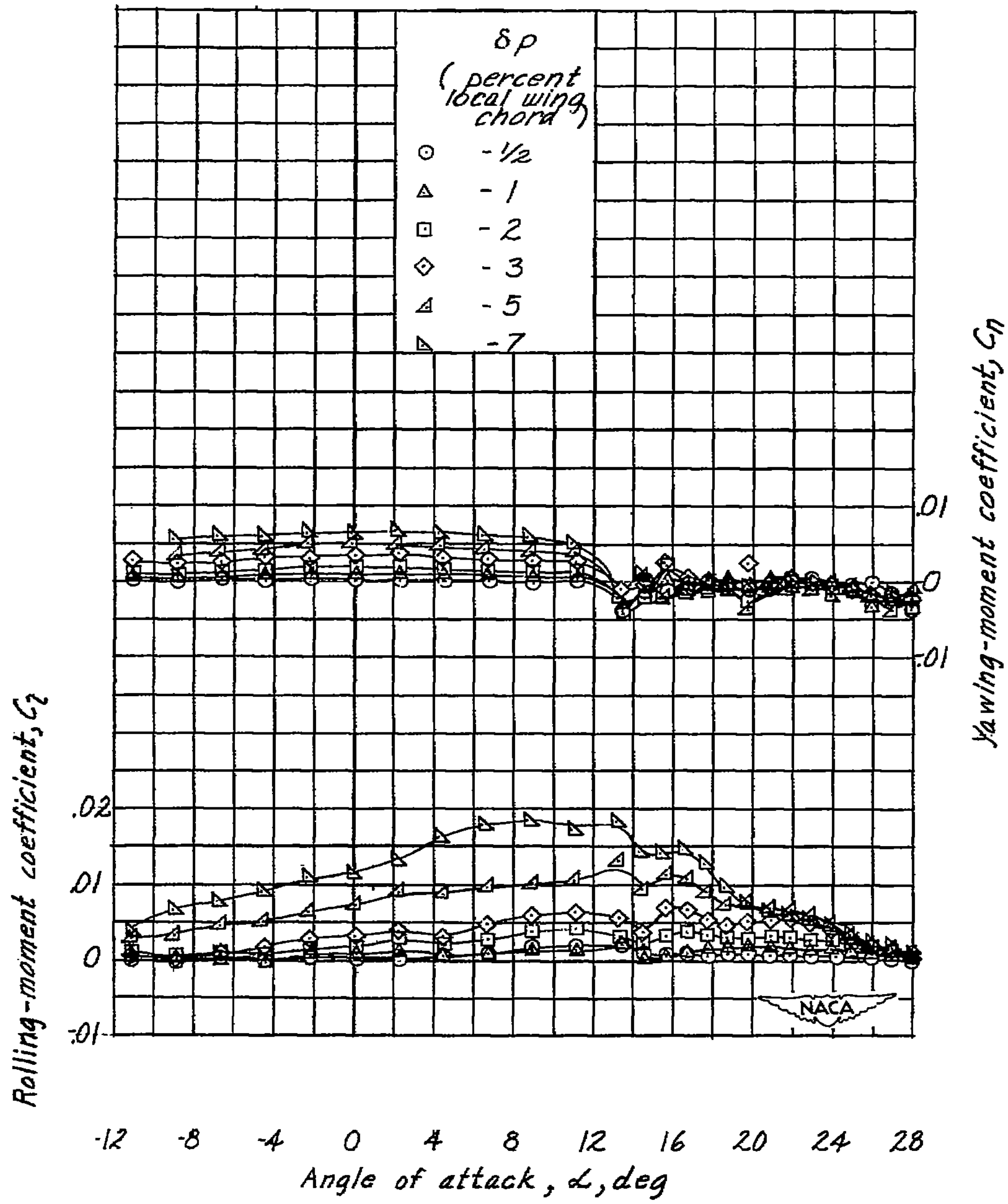
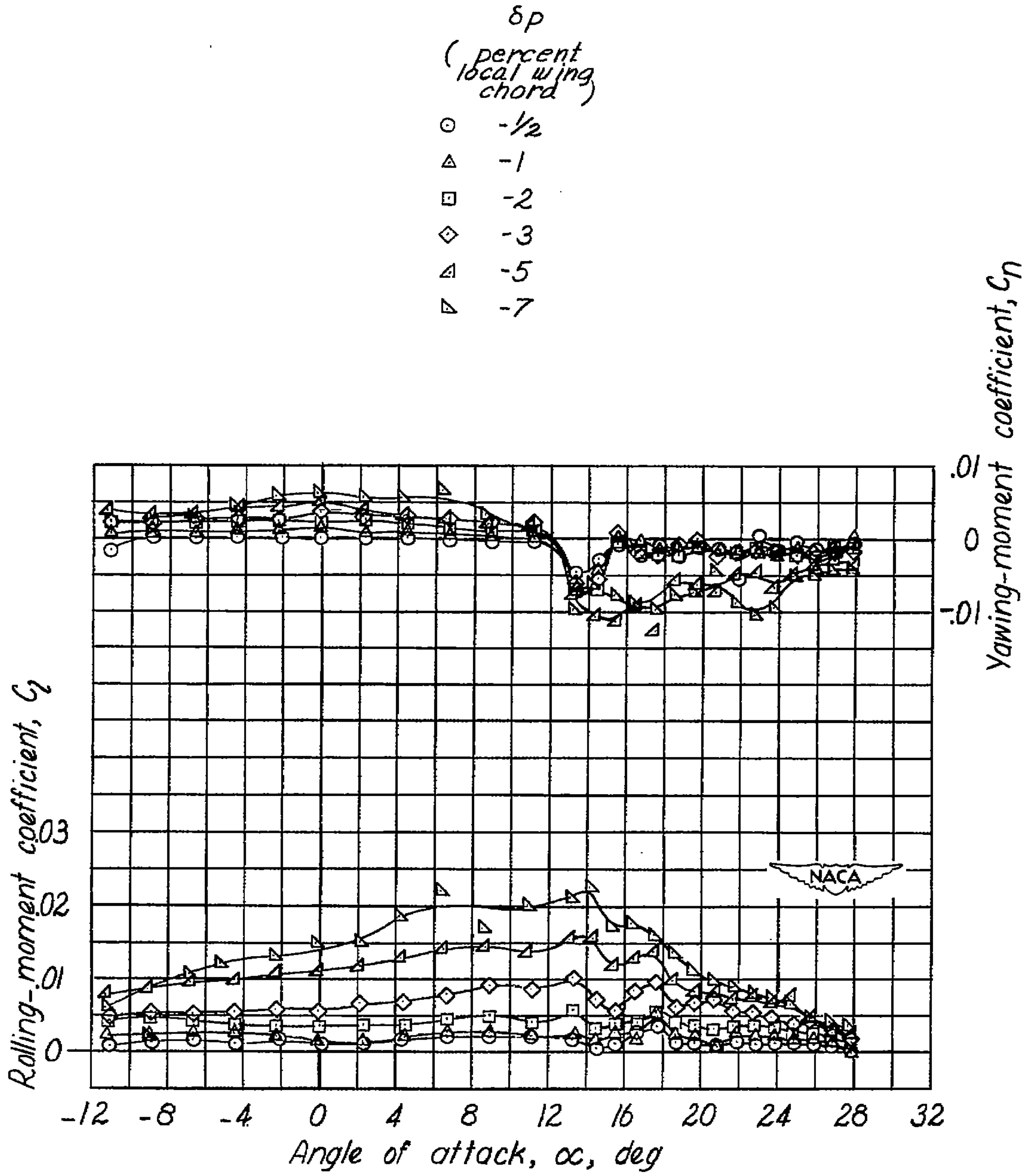


Figure 16. The effect of flap-slot flow-control vanes B on the aerodynamic characteristics in pitch of the 42° sweptback wing with the full-span slotted flap deflected 50°. Flap position, 1 percent below lip.



(a) Sharp plug-slot lower lip.

Figure 17.- Variation of rolling-moment coefficient and yawing-moment coefficient with angle of attack for various projections of the plug aileron on the 42° sweptback wing. Flap retracted.



(b) Faired plug-slot lower lip.

Figure 17.- Concluded.

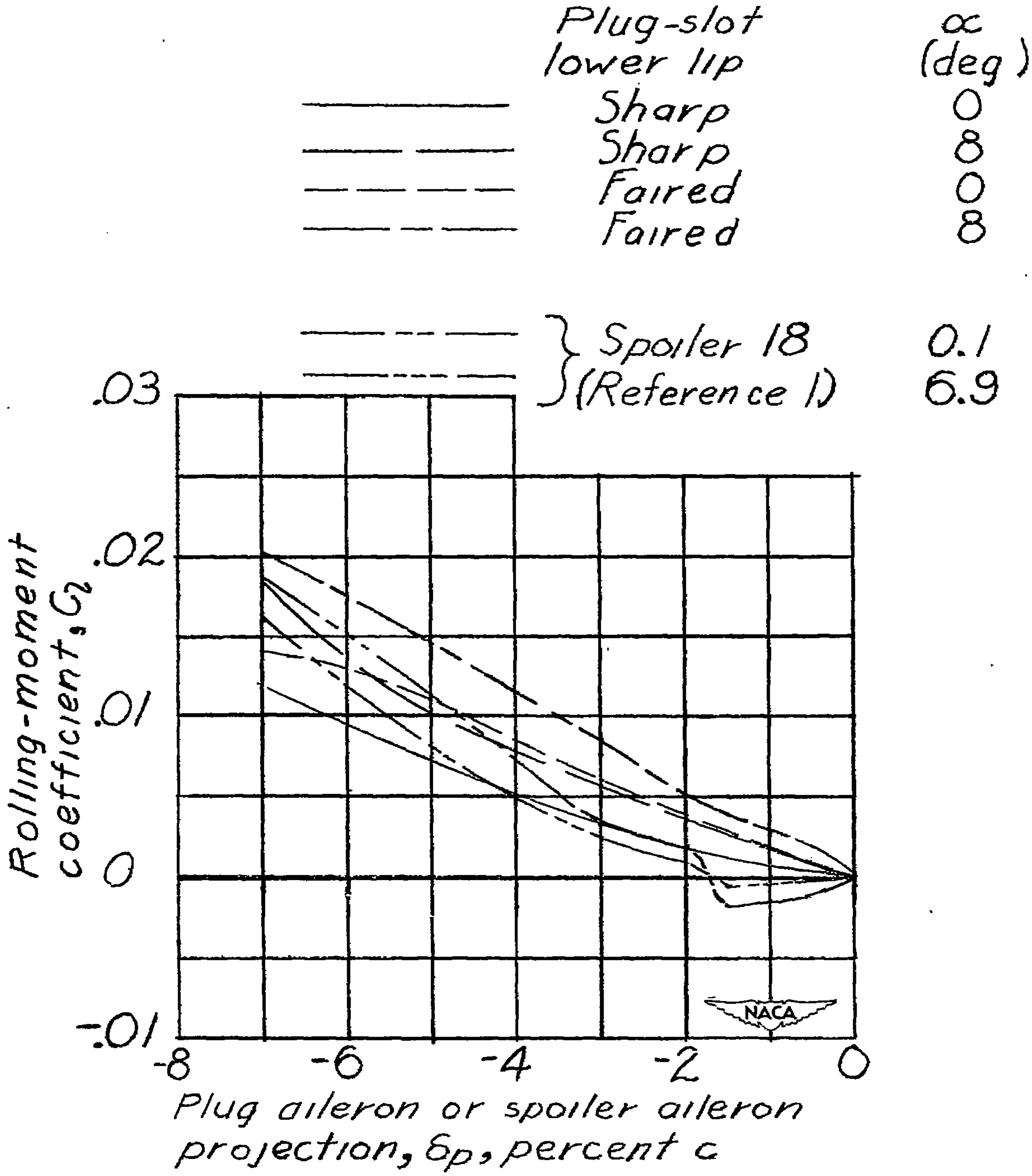


Figure 18.- Variation of rolling-moment coefficient with control projection for various plug- and spoiler-aileron configurations on the 42° sweptback wing. Flap retracted.

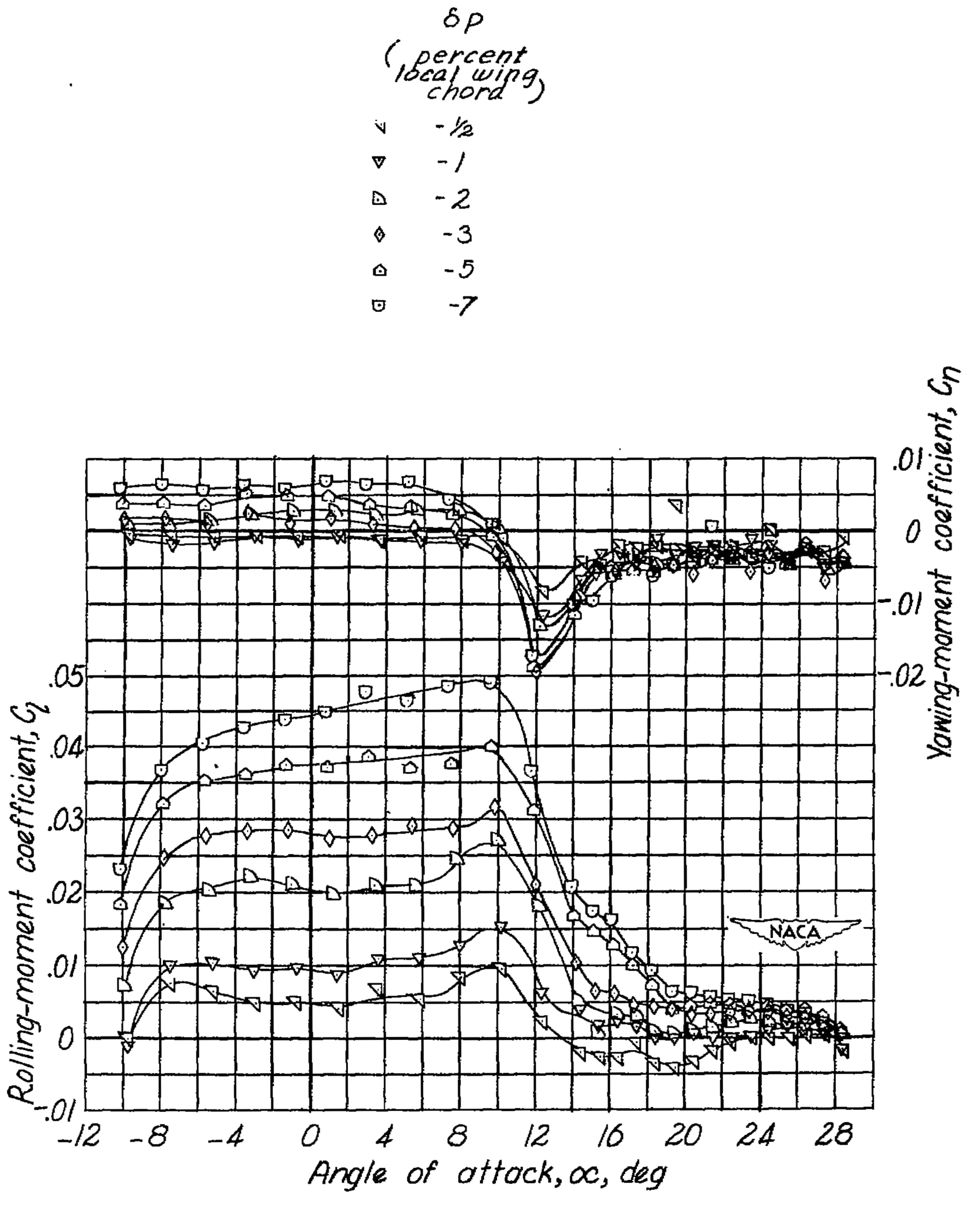
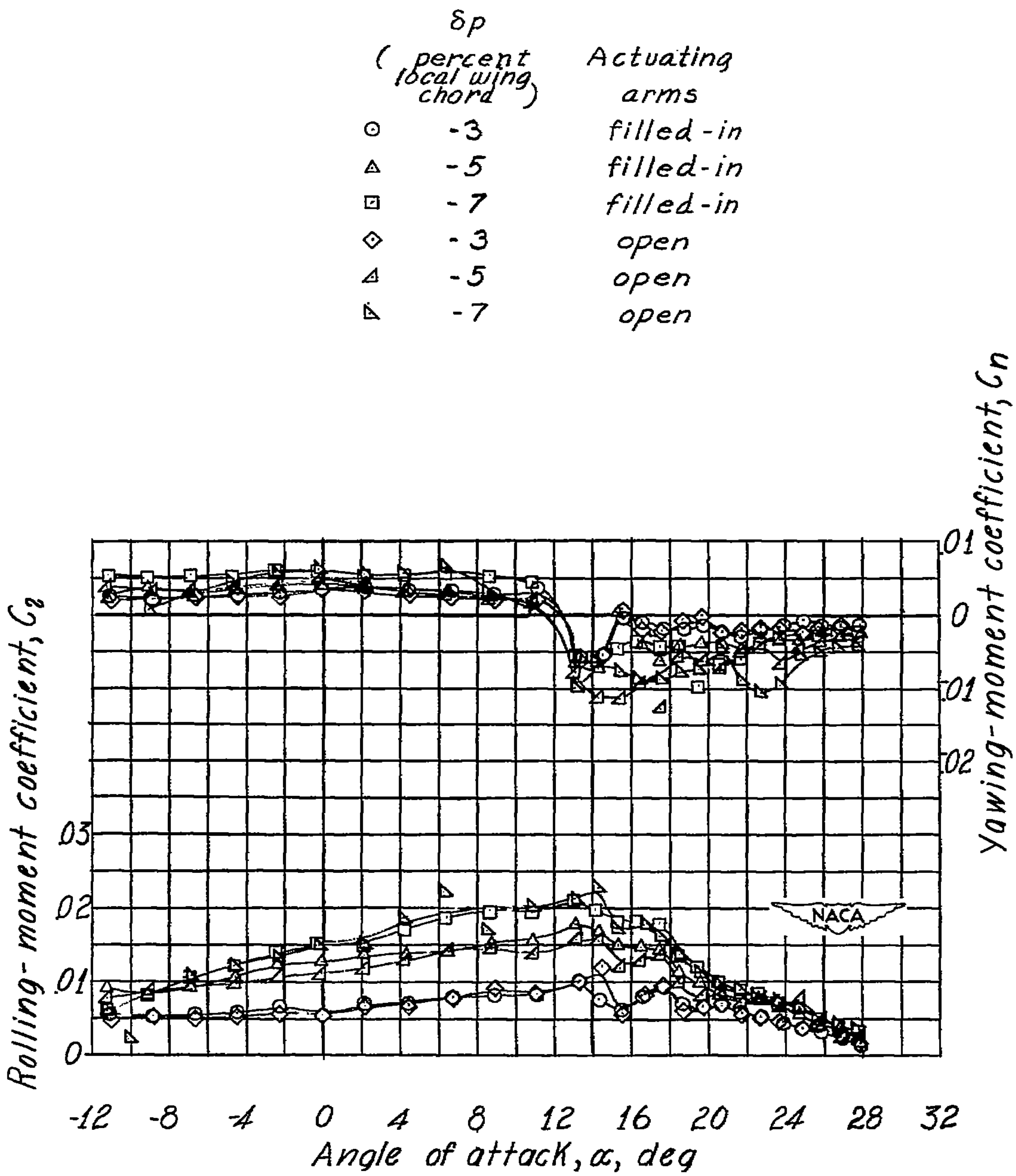
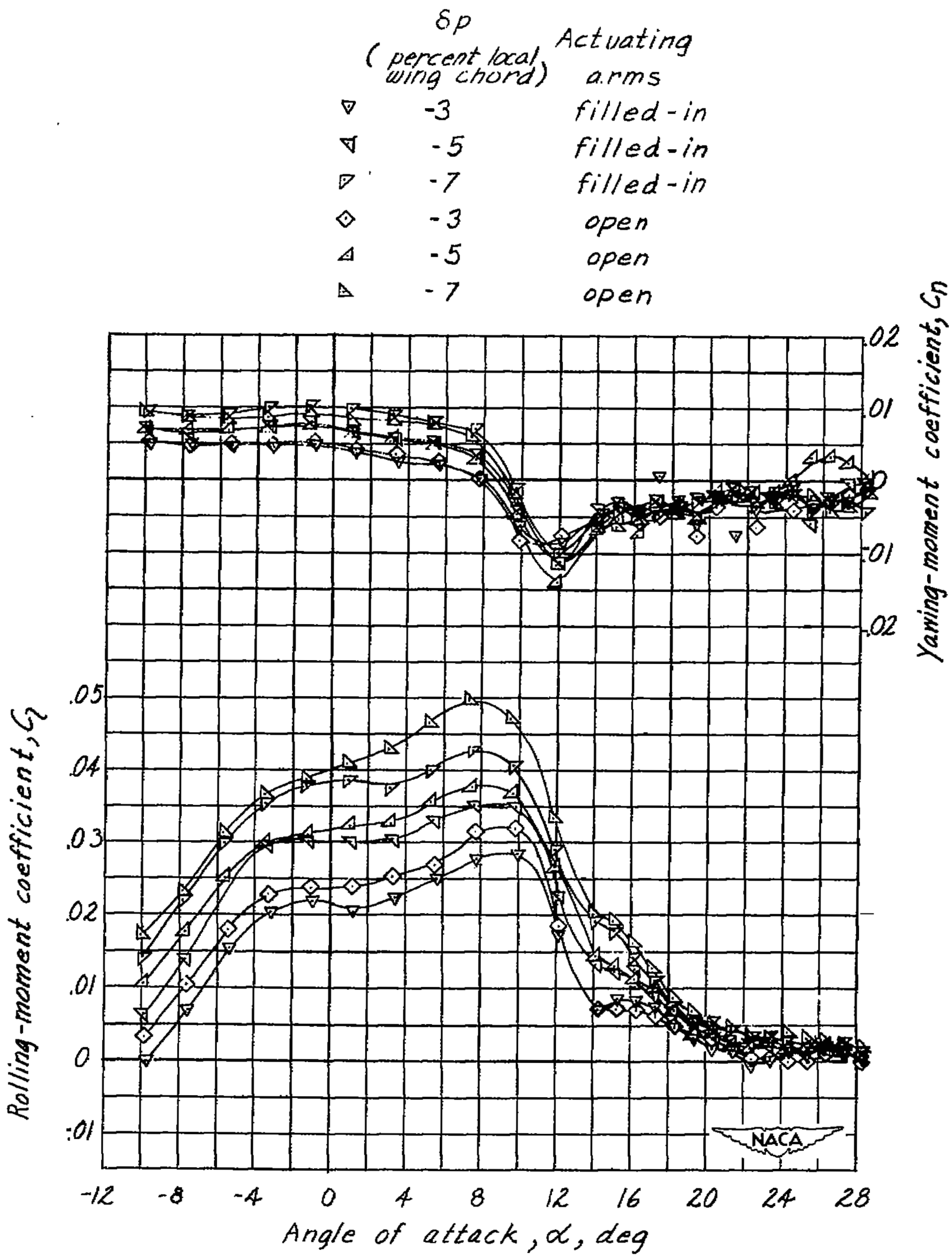


Figure 19.- Variation of rolling-moment coefficient and yawing-moment coefficient with angle of attack for various plug-aileron projections on the 42° sweptback wing. Faired plug-slot lower lip; full-span slotted flap at $\delta_f = 30^{\circ}$.



(a) Flap retracted.

Figure 20.- The effect of plug-aileron actuating-arm configuration on the variation of rolling-moment and yawing-moment coefficients with angle of attack at various plug-aileron projections on the 42° sweptback wing. Faired plug-slot lower lip.



(b) Full-span slotted flap at $\delta_f = 50^\circ$.

Figure 20.- Concluded.

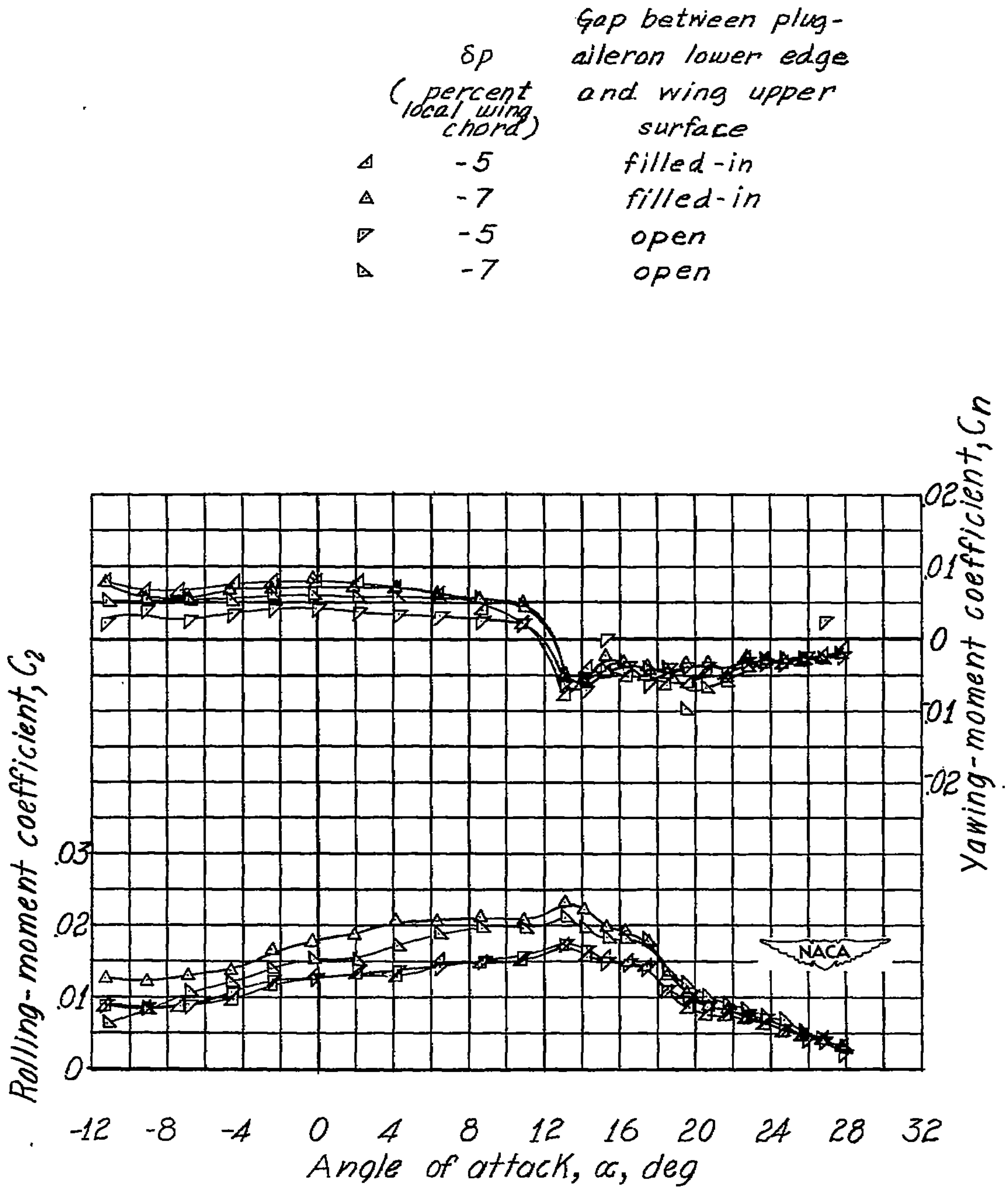
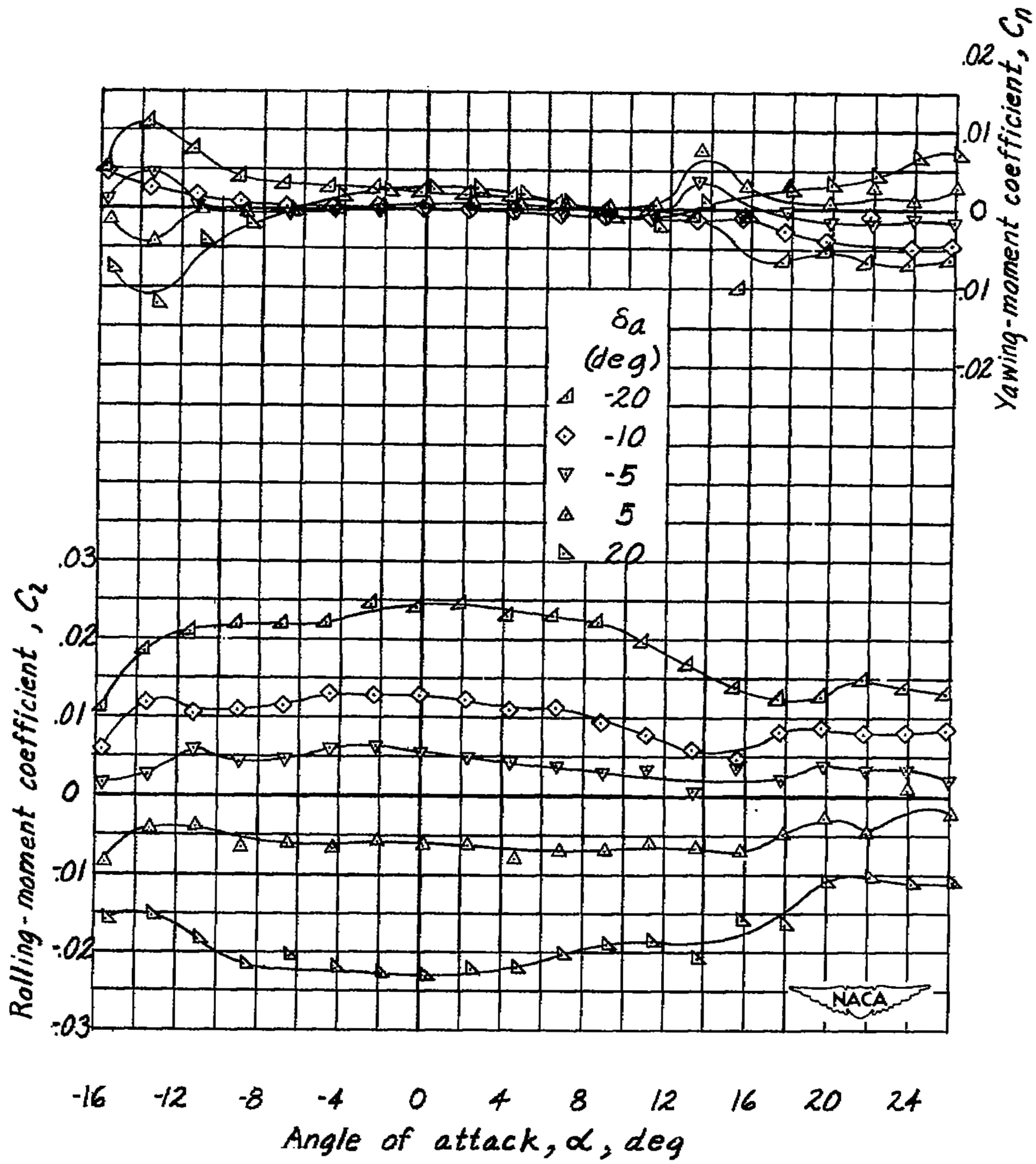
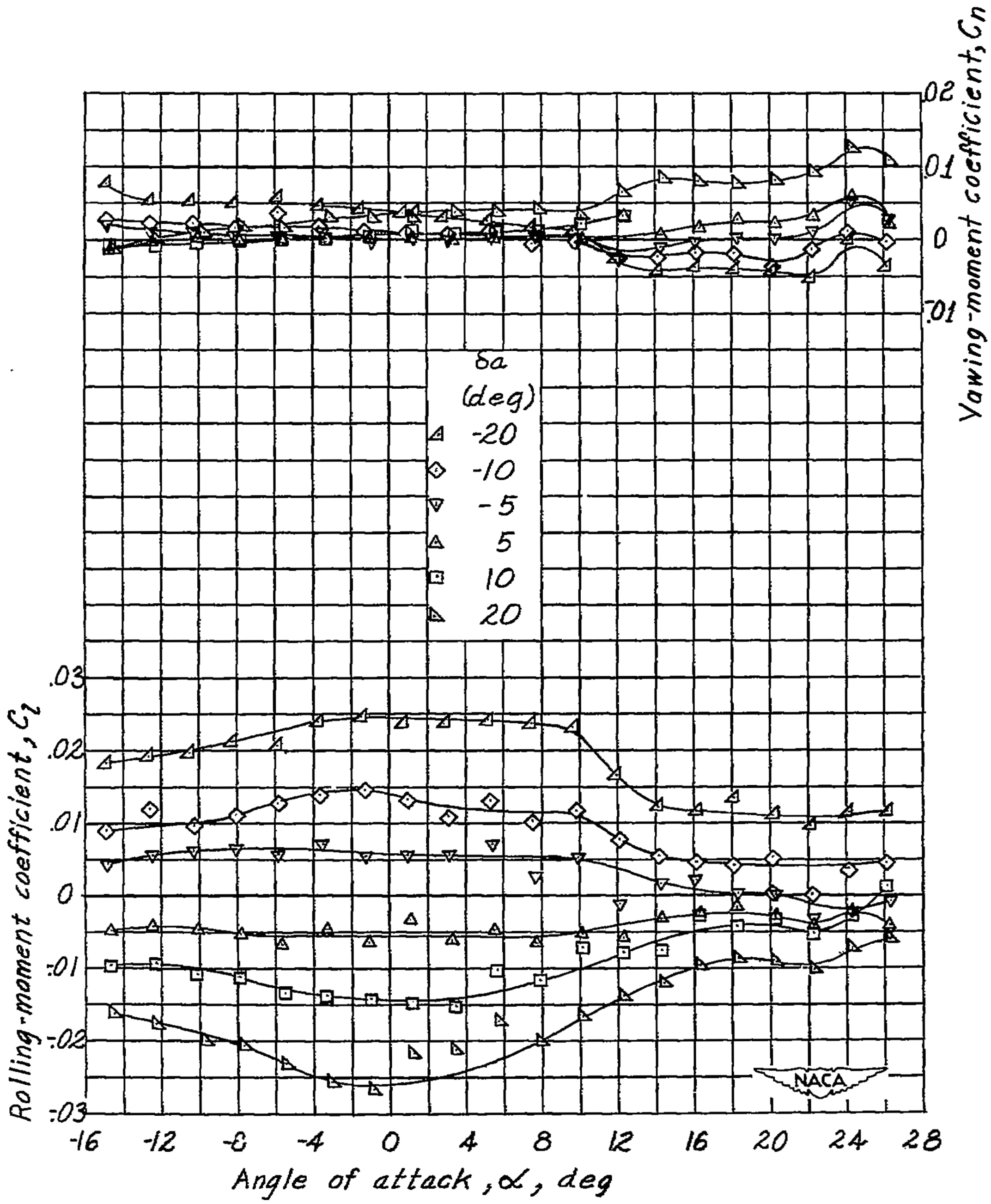


Figure 21.- The effect of a gap between the lower edge of the plug aileron and the wing upper surface at large plug-aileron projections on the rolling-moment and yawing-moment coefficients of the plug aileron on the 42° sweptback wing. Faired plug-slot lower lip, flap retracted, plug-aileron actuating arms filled in.



(a) Flap neutral - flap-slot sealed and faired.

Figure 22.- Variation of rolling-moment coefficient and yawing-moment coefficient with angle of attack for various deflections of a 49-percent-span by 20-percent-chord plain sealed aileron on the 42° sweptback wing.



(b) Partial-span slotted flap at $\delta_f = 50^{\circ}$.

Figure 22.- Concluded.